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A TREATISE

ON

MARINE ARCHITECTURE,

ELUCIDATING

THE THEORY OF THE RESISTANCE OF WATER;

ILLUSTRATING

THE FORM, OR MODEL, BEST CALCULATED TO UNITE VELOCITY,
BUOYANCY, STABILITY, STRENGTH, &c. IN THE
SAME VESSEL;

AND FINALLY

ADDUCING THE THEORY OF THE ART OF SHIP-BUILDING.

BY

Sylver

CAPTAIN M. F. CRISP,

of the country service.

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DEDICATION.

To Rear Admiral Sir Charles Napier, *late Commander in Chief of the Channel Squadron:*

Sir:

A work which has for its object the elucidation or explanation of the elements of a theory to aid the designer to improve Naval Architecture, and to foster and encourage self improvement in our practical seamen, with the view to bring forth the nautical talent and genius of the British empire, as a source of further naval improvement, deserves to be passed through a nautical ordeal of no ordinary kind. The conviction that it will stand this test, emboldens me to dedicate to you the following sheets on Marine Architecture, being convinced of your competence to form an opinion on the various points illustrative of the principles of design. I believe that the nautical world is in debt to you for the true test of all improvements in Naval Architecture, viz: yards of canvass to tonnage. Again, by your having designed the steam frigate Sidon, our national ignorance in the elements of design cannot have escaped your scientific mind, and I scarcely need to add, that my conviction of your competence is strengthened by your able letters to Lord John Russell, on the Steam Navy, and constitution of the Board of Admiralty.

2. Nothing is too insignificant which awakens national precaution. You have pointed out the inferiority of our Steam Navy, and the consequent danger of subjugation by France, so that servile copyists may now apply a make shift antidote by mere mechanical means; yet, however, we remain in the same humiliating position, viz: receiving the initiative in the design of our ships from foreigners; that is to say, England is held in leading strings in the art which is the foundation of her maratime greatness. It must be well known to you that it is not in the power of artistical skill, in the deliniating of a draft, to supply a sound theory of the elements of design; and I contend, firstly, that all improvement must emanate from practical seamen, that the merit rewarding principle should be introduced into every naval department of government, or that Great Britain will become a second rate naval power, growing out of or occasioned by neglecting to bring forth the nautical talent and nautical genius of the nation. Secondly, that she will fall from her present station, unless the political and moral condition of our seamen be elevated to the standard of American seamen. And thirdly, that to escape subjugation by France, our navy must be popular to, or be the ambition of, our best seamen. It is of no avail to have the finest men of war, if they be manned with the seeds of their own destruction, and equally im-

politic to pursue a system which, by keeping the nation in leading strings to scientific pretenders, renders our ships inferior to those of our competitors. I may here observe, that America, by sailing its ships on more economical principles than our ship owners can do, mainly from the disregard of our seamen to their agreement, can compete with us for the carrying trade of the world.

3. A glittering government may give the nation the appearance of strength and prosperity; but when our rulers have reduced the nation to that humiliating position to receive the initiative in our national art of ship building from another nation, and by the selfsame means rendered a powerful class distrustful or averse to join the navy—I forbear to expatiate on this painful subject. It is difficult to foresee the result of any reaction. The strength of Great Britain lies in being the unmistakable pioneer to Freedom. A nation of patriots cannot be subjugated. The merit rewarding principles should be forthwith introduced into the navy. Our navy must be made sufficiently popular to secure the best seamen and best officers from our mercantile navy. The ready made officer system should be abolished. It is that system which keeps the unhealthy or diseased state of our seamen's mind in a state of irritation.

4. I submit that our real national danger, that which introduced the dry-rot into our maratime greatness by destroying nautical genius, was our Impress System. It has reduced the morals and mind of our seafaring classes to the standard of state galley

slaves. There can be but one opinion about the impolicy of demoralising a powerful class by oppressive means, even if we bend that class as a mere machine; but when we reflect that our present ignorance in the design of a safe sea boat is to be attributed to naval mal-administration, we are almost inclined to exclaim, that the nation which tolerates impressment to sap its own maratime greatness deserves to fall.

5. How can there be concert between the constructor, builder, and surveyor, when, for want of nautical genius—a governing, cementing power—they are ignorant of the principles which govern the intended design? The able architect of the Eddystone lighthouse, experienced more difficulty in surmounting the prejudices of his workmen, than the raging of the elements. On the other hand, brazen quacks coerce the public mind to receive fiction for fact. It is extremely difficult for an individual to convince incompetent men in power of their own inability or incompetence to work out a theory. When powerful despotism, and more powerful interested naval patronage, constitute the Lion in the path which obstructs the mental advancement and improvement of our practical seamen above the condition of a Boatswain, the idea of emancipating the machinists from custom, prejudice and ignorance, to enable them to work out the first principles of naval architecture, is out of the question. Instead of discovering any clue wherewith to unravel the skein, the false pretenders to a knowledge of the science have the tact to ce-

ment prejudice and custom into one inextricable mass, leaving but one alternative, viz: that of cutting the gordian knot by pointing out to the nation, as you have done, the unfitness of those in power to manage the affairs of a free maratime nation, in this free trade conpetition age. It is therefore the concern of every interest in the state to elevate the moral standard of our seamen and seafaring classes, and likewise to strengthen their mind and their sentiment of love of country. This state of things, however, presupposes that the line of conduct of our rulers is governed by a system of political economy in accordance with the spirit of the times. All known arts can be made easy. It is the unknown arts which are difficult. So far from having a sound theory on seamanship, we are without a sound theory on the impulsion of fluids. In the absence of a theory on seamanship, and also of a theory on resistance, pretenders to aknowledge of the elements of design only impose on themselves and abuse their influence over the credulous public. Two nations competing for the carrying trade, and consequently for the riches and influence over the civilized world, and one nation being constrained to copy from its competitor, nay even is thwarted by the prejudice of learned pretenders, while the genius, enterprise and patriotism of the other nation is enlivened by freedom, the latter of course must win the race. It never entered into the heads of our hereditary legislators that our mercantile navy is the substratum of our national prosperity, and that to be incompetent to compete with free America in the carrying trade, would be fatal to our maratime and commercial greatness. It never entered into the heads of the Admiralty, that the constructors of our men of war were ignorant of the elements of design. In fact, it is only now that maratime England is beginning to suspect that its admiralty is ignorant of the means and ways to emancipate itself from the humiliating position of being mere copyists in the national art of shipbuilding. Pretenders who charge themselves with the functions of naval architect, deserve to be impeached. In cloaking their own and their patrons' ignorance, they prevent the force of practice exposing erroneous principles. A knowledge of our want, is a good first step towards working out a sound theory to supply that national want. Our naval power at present resembles a boa-constrictor in a torpid state, from which state nothing short of free trade, in government can rouse or reanimate. No art, whether it be the government of a state--of the Admiralty, or the art of naval architecture, can prosper, unless first principles are kept in view. A yacht or packet intended for speed only, should have but one main frame, and be built of light materials, and be shallow—all run and entrance; whereas a vessel intended for capacity, must have many dead flats or main frames. Thanks to the power of steam, the list of pretenders to a knowledge of the science of naval architecture is fast diminishing, while that of experienced experimentalists is fast increasing. Boats sailing in smooth water, their speed is in powerful sails. A mere platter, having a deep keel affixed to it, would, in smooth water, from its power to support enormous sails, outstrip a boat intended for sea. On the other hand, in a seaway, from the motion of the platter, arising from the vertical effort of the sea, it would be in great danger of being dismasted. The platter would have no chance with the boat in a seaway. The principles which govern the useful qualities of a safe sea boat are, therefore, widely distinct from the principles which govern the lines of beauty, to set off the head or quarter galleries, or which govern fast sailing in smooth water.

6. False theories on seamanship are apt to mislead the young naval officers to adopt the belief that they possess a scientific knowledge thereof; on the other hand, draftsmen disdain to receive from common seamen any hints or information on the elements of design; meanwhile, the practical sailor is forbade by the attending expense in building a series of experimental vessels, from giving form and effect to his ideas of ship building. It is from this unnautical state of things that other nations outstrip us in scientific attainments in the art of ship building, and also in the art of cheap government.

7. In all practical sciences, but more especially those in which the judges are utterly ignorant of the principles, perhaps incapable of grappling with the ideas to form an opinion such as that of government or the art of ship building, the advocate has to qualify the judges; that is, he has to do an impossibility before he can submit his case for decision. Aware

of the difficulties and prejudices which you may have experienced in completing the design of the Sidon, I offer the following remarks to fix or concentrate some fugitive ideas on the science of ship building, for the benefit of all judges on naval architecture.

8. I may here premise, that the form of a solid of the greatest capacity is that of the circle, and that in order to unite the form of velocity, with that of capacity and buoyancy, all the water lines should be segments of circles. This I consider to be the fundamental principle in naval architecture. Concave water lines, like concave wedges, are detrimental to advancement.

9. Stability is the next consideration. The main frame governs stability. A broad flat floor gives the greatest stability; but we cannot, however, sacrifice the power of lateral resistance of the keel. Fifteen degrees being the angle to which a vessel heels over in a fresh breeze, I conceive this to be the angle for the rise of floor of a merchant sailing ship.

10. I may here observe that as the form of the main frame does not materially affect velocity, steamers may be formed with fallen floors, on the double canoe principle. This form, from its increased stability, would admit of greater length to breadth, and at the same time, by giving additional depth to the side, give additional longitudinal strength.

11. The dread entertained by our ship owners, as to their ability to compete with success for the carrying trade of the world, after the total repeal of the navigation laws, evinces some degree of conscious

inferiority. Want of confidence leads to defeat. I would here remark, that our unnautical ship owners are either in a false position, or that our merchant ships, or merchant seamen, are inferior to those of America. Knowing that they have ground for their apprehension, I would recommend that the state insure the blocks of all our merchant ships of the first class, at a low premium, previous to the total repeal of the laws. It is bad policy to place the carrying trade in jeopardy. It is worse policy to suffer England to be in danger of subjugation by France, from an inferior steam navy. While it would be utter madness to endanger our fleet by tolerating the belief in impressment.

12. Faucity of nautical genius is our bane, and the parent of scientific ignorance, respecting the elements of design, owing to which our practical ship wrights not merely misapply their practical skill, but their ideas of durability and strength being based on false principles of economy, subvert the good qualities of a vessel.

13. Until a sound theory of the elements of design be established, I am of opinion that our war steamers should be constructed of light materials; for this plain reason, that heavy materials affect velocity and buoyancy; again, want of pliability, arising from great strength and consequent overfastening, affects velocity. Since then the inferiority of our war steamers in regard to speed involves the question of national subjugation by France, and as the want of nautical talent and genius is to be attributed to naval

patronage and naval despotism, the real question before the nation is, shall naval patronage be fostered, or shall the merit rewarding principle be established to reinvigorate Britons to remain the pioneers to freedom and to civilization.

To the philanthropist it is of little consequence wheresoever that genius and civil liberty flourishes the best, so long as they do flourish for the benefit of science and the human race. The patriot, however, deeply feels the sneer and scorn which follow the decline of his nation's greatness. The same cause which creates a system of dry rot to sap the talent and genius of this maratime empire, renders our ships inferior, to end in loss of commerce and loss of colonies.

I have the honor to remain, your most obedient and humble servant,

M. F. CRISP.

Maulmain, Oct. 16, 1849.

PREFACE.

Leaving to others the office of tracing the origin and progressive advancement of Marine Architecture, sufficient remains to be done to describe the properties which vessels must necessarily possess to be perfect sea boats; to elucidate and explain the manner of obtaining those properties; and, finally, to unite them in the same vessel, that each may be predominant without deteriorating from the others.

Of the many writers who have written on Marine Architecture, no two of them have agreed in proportioning the breadth to the length, or the depth to either breadth or length—or in placing the extreme breadth, or the centre of gravity, or centre of displacement, or centre of lateral resistance or rotatory motion,—the position of the masts,—nor on the form best adapted to produce velocity, buoyancy, or natural stability; much less on the model or form best adapted to unite the above properties or qualities in the same vessel, which is proved by the variation in every succeeding vessel built. Their nearest agreement has been to determine, that "the breadth should " be one third or one fourth the length, and that the " extreme breadth ought to be before the midships of " the ship."

The obscurity in which the true principles of Marine Architecture continue to be involved, may be attributed—

1st. To the disinclination of draftsmen and builders to communicate freely with experienced seamen. And,

2dly. To the mode of admeasuring vessels to obtain their register tonnage, whereby ship-owners and ship-builders are interested in constructing ships after one form or model, namely, that form which enables the vessel to carry one third to one half more cargo than its register tonnage, with the view to evade that proportion of the tonnage, and light and harbour dues, and to sail their vessels with a proportionable smaller crew. While, therefore, improvements are obstructed by professional prejudices or interested motives, or theories consulted that are founded on erroneous or narrow principles, it will be next to impossible to extricate the rudiments of this noble science from their present obscurity. Some years after the first edition of this work appeared, the present new mode of measuring for register tonnage was enacted.

To have a just idea of the theory of Marine Architecture, the mind must be divested of professional prejudices; the laws and the causes of resistance of water must be carefully investigated; and in fact we must

" E'en follow nature, of each art the soul:
" Parts answering parts, shall glide into a whole,
" Spontaneous beauties all around advance,
" Start e'en from difficulty, strike from chance," &c. &c.

A fish, for example, conveys a good idea of the form of a vessel intended for velocity; but it gives no idea of that of stability or buoyancy, or weatherlyness; qualities that are indispensible for the safety of a vessel.

On the other hand, the form of the albatross, the duck, and other water fowls, gives a good idea of the form best adapted for buoyancy, but no idea of that of velocity.

As, however, a vessel is not required to have the same degree of velocity as the fish, the practicability may be conceived of reconciling in some degree the form of the albatross to that of the fish, and thereby unite in the same vessel the four most essential qualities, namely, velocity, capacity, weatherlyness, and buoyancy.

A vessel calculated to keep on an enemy's coast with all winds, or to work off a lee shore, must have good hold of the water, and therefore be deep in the water to hold a good wind; whereas a vessel intended to navigate in shallow water, or to take the ground, must have a flat and a long floor, and therefore be shallow, in order to draw the least water, and to avoid straining when she lies on the ground.

Nature formed flat fish to lie securely on the bottom, and to inhabit rivers and shallow water; whereas the dolphin and other fleet fish that inhabit the sea, are formed deep, doubtless to add to their velocity.

The principles or standard by which to govern the form for velocity in a vessel intended for smooth water, are widely different from those which govern a sea going vessel. Again, the modification of the principles to govern velocity in a vessel intended for speed only, and that of a vessel for capacity, are widely different.

The perseverance with which writers on Marine Architecture have endeavoured to give the same properties to vessels that are intended for different purposes, has much impeded the advancement of the art; and when to this be added the notorious prejudice and adherence of ship-builders to old habits and customs, we need not be surprised to find them governed in the form or model of the vessel to be built either by precedent, caprice, or convenience, and that this noble art has not advancd one step beyond practice.

The professor Inman, after translating Chapman's celebrated work on Marine Architecture in 1820, is constrained to confess: " The construction of a ship
" with more or less good qualities, is a matter of
" chance, not of previous design; and it hence fol-
" lows, that so long as we are without a good theo-
" ry on ship-building, and have nothing to trust to
" beyond bare experiments and trials, this art can-
" not be expected to acquire any greater perfection
" than it possesses at present.

"It becomes a matter of importance, then, to discover what may bring this knowledge to greater perfection. Seeing that ships, the proportions of which lie within the same limits, nay, which have the same form, differ greatly from each other in respect to their qualities, and even that with a small alteration in the form, a ship acquires a quality immediately opposite to the one we wish to give it, we must conclude this arises from certain physical causes; and that the art of constructing ships cannot be carried to greater perfection, till a theory has been discovered which elucidates these causes."

It must be manifest to every amateur, nay, even to the most superficial observer on Marine Architecture, that while the theory of resistance of water, and of impulsion and of seamanship, (the foundation of Marine Architecture,) remained unknown, the theory of Marine Architecture would remain undiscoveerd, neither could the art be much improved by the writings of our ablest mathematicians. Hence Euler's elaborate work on the construction and properties of vessels failed to afford the improvements in the art, which the author and translator evidently contemplated. In page 93 and 94 of that work, is the following remark relative to resistance:—"But as the theory of resistance which we have hitherto considered, must be allowed to be very defective, and that we cannot entirely depend upon the conclusions which are drawn therefrom, we may well spare ourselves the trouble of such difficult researches. For although we have already supposed

" that the simple pressures which the body of a vessel sustains when in motion, do mutually destroy " each other, yet we are certain this can only happen when the vessel is at rest, since the water behind the vessel must follow and overtake it before " any pressure can be exerted; it is therefore evident, that the pressure upon the aft part cannot be " so great when the vessel is in motion, as when it " is at rest; whilst the pressure upon the fore part " will nearly be the same in both cases. From " whence it follows, since the pressure upon the fore " part is no longer counterbalanced by that upon the " aft part, the effect of this resistance must necessarily be increased; and this increase will by this " means be so much the more considerable, as the " velocity of the vessel becomes greater; and however little consideration we may employ upon this " matter, we may easily conceive that this increase " must depend principally upon the figure of the aft " part of the vessel, which we have hitherto entirely " neglected. On this account it appears very probable, that notwithstanding all our endeavours to " determine the exact resistance, we may perhaps " still vary considerably from the truth." And in a more recent work on resistance, (Robison's Mechanical Philosophy,) the author concludes by observing: —"Thus have we attempted to give our readers " some account of one of the most interesting problems in the whole of mechanical philosophy. We " are sorry that so little advantage can be derived " from the united efforts of the first mathematicians

" of Europe, and that there is so little hope of greatly " improving our scientific knowledge of the subject. " What we have written will, however, enable our " readers to peruse the writings of those who have " applied the theories to practical purposes. Such, " for instance, are the treatises of John Bernoulli, of " Bouger, and of Euler, on the construction and " working of ships."

My object in adverting to these remarks on resistance, is with the view to unbias the reader's mind, and at the same time to give him some idea of the obscurity and difficulty of the subject.

After twenty years experience and close observation on the properties of various vessels, under every circumstance, at sea, I became convinced of the causes which more or less affected their good or bad qualities. This conviction impelled me to investigate and comprehend the laws of fluids; and this again led to the important discovery of the predominant cause of resistance, which retards the velocity of all bodies when they are passed quickly through the water.

The following Treatise commences with a concise account of the laws and resistance of fluids, which the avocation of a seaman but little qualifies him to elucidate in a pleasing or agreeable style. It then proceeds to elucidate and explain the causes that produce, or which more or less affect the good qualities in a vessel,—reconciles those causes on theoretic principles,—and finally demonstrates some of the principles of the design or art of constructing vessels, in so plain a manner as to render the subject easy of comprehension to every reader.

From the various kinds and various forms of vessels that navigate the Indian seas, and from the cordial interchange of liberal opinions and sentiments between gentlemen of different professions, more especially those of ship-building and seamanship, there is no part of the world better qualified to appreciate the observations and remarks contained in the following sheets than India. If, therefore, this effort to improve the art of ship-building should evince error in judgment, the author has the consolation to know, it cannot be impeached by the choice made of the tribunal to try the merit of his performance.

INTRODUCTORY OBSERVATIONS.

Such is the influence and force of bad customs or bad laws that they can extinguish mechanically the germ of national genius. Follow, for instance, the effects and consequences of the custom and form which the old mode of admeasuring our ships for their register tonnage had established in ship building; again, trace the bearings and consequences of the custom of impressment, when it will be seen that our rulers and law makers not merely disregarded nautical talent and genius, but disregarded the sentiment of love of country, and of loyalty in our seamen. In destroying the talent and genius of our seamen, wê destroy the life of our maratime greatness. It is one thing for intelligence to apply the power of passive resistance as an antidote to bad government, and another thing for the government to destroy the life of national greatness to uphold patronage. The statesman whose rule of conduct is warped by the desire to make ignorance and subserviency bliss, destroys his posthumous fame, nay cuts the hair which suspends the sword over his head.

Among the numerous evils growing out of the toleration by the press of bad customs, is the facility with which customs enthral the mind by obtaining concessions by convention. The credulous very naturally presuppose that their rulers possess a thorough practical knowledge of our national arts, viz: seamanship and ship building, whereas their ignorance is in this competition age fatal to our superiority in our mercantile and steam navy.

Successful fraud, like other evils, increases by what it feeds upon. On the one hand, dupes dread to confess that they have been imposed upon, or to admit that they are wiser to-day than they were yesterday, while impostors become disqualified to set in judgment, or to discover the principles of a science, the discovery of which would convict them of having received public homage undeservedly. Not so, however, with the high minded, of professor Inman's standard. One of the most scientific ship builders in India, my friend Mr. James Kyd, admitted, a few years after the publication of the first edition of this work, in 1826, that ship building was in its infancy. The following extract from Mr. White's book on the theory and practice of ship building exhibits this gentleman's opinion to be similar to the professor's, viz: that the why and wherefore of the elements of design must emanate from the genius or practical observation of the experimenter or practical seaman. In chapter II, page 27, in White's "Theory and Fractice of Ship Building," he observes, " that after a most careful analysis of the various wri-

" ters, at home and abroad, (the best compendium of " whose names and nostrums may be found in the article 'Ship Building,' published by A. F. B. Creuze, " esquire,) we can derive from them no satisfactory " conclusion about the *data* on which to construct a " ship, so as to give 'the why and the wherefore' to " a demonstration. It would be worse than affect" ation to attempt it here; for while the able author " just named has deplored the want of superior edu" cation in many practical men who might have fur" ther benefited the science, yet we cannot shut our " eyes to the fact that the school in which he was " trained, which existed for above twenty years un" der the most favorable circumstances, sustained by " government resources, and which has had more " than half that time since to exhibit its fruits, has " done but little to advance the science, so far as po" sitive qualities go, in the ships they have built, or " even to illustrate the theory of their construction; " we therefore look *onward* for this desirable con" summation, not doubting that the bringing so many " more mathematical minds into the field will be of " great avail, when science shall have developed the " laws of fluids, and told us how the water really " moves under and about a ship in motion. At pre" sent, instead of proposing to build ships upon any " established or known theory, we avow our inten" tion to be, that of deducing the draft from the form " of vessels of decided superior character, and in " this way to supply the want of sufficient data upon " which construction *should* proceed; we need not

" wait until the curve of the solid of least resistance " has been ascertained, but by experiment, proceed " with that form of body which is found to unite the " several requisite qualities."

Admiral Sir Charles Napier, in one of his letters to Lord John Russel, asks, "who is responsible for allowing so many ships to be built after the plan of the late surveyor? Either his plan is good or bad. If bad, why were so many ships built after it?" "I shall be told," continues the Admiral, "the naval officers are there to instruct (unnautical first lords of the Admiralty) as to the best form of a man of war. I can only reply, that experience has proved that it does not answer."

The injudicious disposition of weight on board a vessel, but more especially on board a long steamer, at either extreme, will destroy her good qualities against a head sea; on the other hand, a quantity of bilge water will destroy the sailing qualities of a yacht. The principles of the data or elements of design not merely involve a sound theory of resistance and impulsion of fluids, but the proportions, the dimensions, the form, and the fastening and weight of the materials of which the vessel is built; in addition to which the experimenter is presupposed to possess a knowledge of the science of seamanship, to be qualified to test a safe sea boat; that is, a safe vessel when the elements take command. Such is the vertical or centrifugal force of a heavy sea on a broad vessel, to bring her deck parallel with the slope of the sea, that the guns could not be cast loose, while her masts would be endangered; whereas a narrow vessel, from being deeper in the water, is not only more under the influence of the earth's gravity to keep the deck parallel with the horizon, but is less under the vertical or centrifugal force of the passing sea. I may here remark, that a vessel which sails the fastest free, can escape from an enemy which sails only fast by the wind; whereas, from change of wind, the vessel which sails fastest by the wind, cannot escape from an enemy's vessel which sails fastest free. I have long since conceived the idea that want of strength longitudinally is the only limit to length, and that additional strength may be obtained if required by carrying the keelson and sister keelsons up to the holdbeams; whereas it is only a few years ago some of our learned professors proved it to be mechanically impossible that long vessels could be safe sea boats.

The danger of England being subjugated by France, as pointed out by the late Commander in Chief of the Channel Squadron, arising from our national inefficiency in naval architecture, is a good and valid reason to make an effort to untie the knot by which the nautical mind of the first maritime nation is held in thraldom. Another valid reason is exhibited in the published accounts of the superiority of a class of merchant ships belonging to America over that if our merchant ships, thereby indicating our inability to compete with free America for the carrying trade of the world, of which the *Sea Witch* is a muster and example. A third reason is the apparent prostration of nautical enterprize in some of our authorities, by pronouncing their several vessels inefficient to proceed to save some of the crew from the wreck of the ship Emily, recently lost on an island of the Andamans, whereas, in the days of Columbus, inferior vessels proceeded on voyages of discovery.

It is one thing to conceive the idea that naval mal-administration may accelerate the decline and fall of our maritime greatness, and another to establish that belief in the public mind. It is one thing to trace to its source an evil which involves loss of position in the scale of nations, and of which evil those who exercise the functions of government are the causers, and another to convince the public by an appeal to its understanding of the direful results that must follow, by the state remaining wilfully blind to the facts of the case. No art or science is unsusceptible of advancement. On the other hand, every art may be lost by the influence of despotism, or ignorance. Meanwhile, nations lose their influence over the civilized world, just as their cotemporaries are in advance of them in the useful arts. Are Britons to be in nautical science and politics selfdoomed to become a third rate power?—that is the question. I opine that my countrymen only require to be informed where the hitch lies to cut the knot forthwith. This is the object of these preparatory observations, or introduction. I attribute our national ignorance in the science of naval architecture to naval mal-administration, and as it is impossible to treat this important national subject with that degree of conciseness as to prevent apparent repetition of the same idea in various efforts to elucidate particular principles, I must on this account solicit the reader's indulgence.

The well disciplined nautical mind, being constrained to prostrate itself in naval affairs to minds of conventional attainments and to press masters, become disgusted, and as a matter of course sinks in its own and in public esteem.

A state of society which is highly artificial, not merely cultivates a spirit of subserviency, but converts its most talented needy members into its willing dupes, victims, and intruments—(witness the sons of our aristocracy as press masters.) In the end, however, its rulers, though supported by a venal press, acquire a species of delirium tremens at coming events, which their knowledge of the power of passive resistance in the people, together with their false position, all tend to accelerate. The false position of our Admiralty, in regard to naval architecture, arose from this state of things.

Facts and results are the grand data of improvement. The fact that merchant ships belonging to America, (which only last century was a British colony,) can compete with our merchant ships, by being navigated with a less number of seamen than that of our ships, indicates that free America is about to take the initiative in nautical affairs. In every art there is a tact, the principle of which is in the mind; it is that self improving power of freedom acting on the mind, which enables freemen to build cheaper ships than even the slave, or debt bondsman. Our American colonists, for example, can build cheaper ships than our Burmese colonists. The alacrity with which a few riggers can and do fit out ships, proves to a demonstration, the value of intelligence and experience to aid manual labour. Mechanical skill implies mental superiority, and in regard to ship building, two thirds of the cost is paid to the laborer. The political economist who should disregard the power of freedom on the mind, builds his system on a sandy foundation. The experienced statesman, also, knows that the measures of a popular government are made to produce good results, regardless of the motives or intentions of the originator; whereas the best intentions of a set of imbeciles, or usurpers, who exercise the functions of government without possessing the confidence of the people, are rendered unpopular, for this obvious reason, viz. whatever runs counter to "the greatest good of the largest number, for the longest period of time," is opposed by the spirit of an intelligent age. Education teaches the rights of man. An intelligent labourer is averse to work to benefit the revenue drones.

In our search for data as a basis for a theory as a starting point to advance an unknown science,—the laws of magnetism, for instance,—it is obvious that we should employ practical men of genius to record the various phenomena under every circumstance, of climate, and latitude, and storms affecting the dipping needle; and besides, the experimenters must know how to protect the needle and to keep it free from local influence, otherwise their recorded observations would be worse than useless. The idea of employing unlettered practical seamen to work out a magnetic theory, seeing that with them they entertain a preconceived theory about the only duty of the needle being to point to the North, would be absurd; they would ridicule the idea of making the dipping needle a means to find the latitude. When we therefore consider that a ship in a seaway is more complex than the dipping needle, it being of various forms and dimensions, and of different weights, and acted upon by the impulsion and resistance of fluids, the idea seems to me equally preposterous for builders, draftsmen, amateur seamen, or admirers of architectural elegance, discovering a sound data for the elements of design, as in their opinion there remains nothing to be discovered or to be learned, while others would have their experimental model a solid, the form whereof had the curve of least resistance, tested, by the way, by some imaginary centre, to wit, the point velique, or meta centre. On the other hand, I mantain, that this is the proper office of the practical sailor, who requires a solid of the greatest length, at the same time possessing the greatest resistance to lateral and to downward motion, as his experimental instrument or machine. On this account it is of the first importance for science to elevate the intellectual mind of the nautical world. It is a fatal error on the part of Great Britain to accelerate the mental debasement of their practical seamen by tolerating the belief about impressment being a national evil without a remedy. This mental incubus acts like fear. It is not only the cause of mental debasement, but it nips nautical talent and genius in the bud, and misleads the men of science.

Government very willingly affords every encouragement to facilitate improvement in manufactured articles, by rewarding and honoring those of skill, be it practical, mechanical or chemical; whereas our naval patronage system dwarf's nautical genius and talent, to accelerate the decline of our maritime greatness; that is, the whole force of government is misapplied to prevent the growth of liberal political principles, by which the mind, talent and genius of our seamen and seafaring classes might save the nation from becoming a second rate naval power, by improving our knowledge in naval affairs. It is easier to depress the standard of freemen to that of bondsmen, than it is to elevate bondsmen to that of freemen. The custom of impressment, together with false education, can readily effect the former, the soil being previously prepared for the seed; whereas, in regard to the latter, from the soil and seed being deteriorated, it requires the example of genius and talent to enable nautical knowledge to stem the torrent of custom, prejudice and book education, which have depressed our seamen below their proper standard.

Statesmen must be judged by the result of their measures on the bulk of the people. The state of mental prostration in our seamen and seafaring classes, evinced by the absence of any rational principle or theory to develope the elements of design of naval architecture, together with that apparent want of loyalty and love of country indicated by their wholesale emigration from our navy, at the appearance of war, are fruits of unstatesmanship which exhibit the rottenness and poisonous nature of their upas tree. It is obvious that in this free trade age other principles more in accordance with the age must be adopted to sustain our maritime greatness.

The true sign of the decline of nations is that of subserviency to the powers that be. The people worship patronage and the cunning tactician, instead of enterprize, merit and intelligence. Genius, talent and enterprize cannot flourish in a prostrate mind. Instance the prevailing naval belief that we must have recourse to impressment on the sudden break out of a war. Instance our inferior war steamers. Instance the dread of our ship owners to compete with the improved class of merchant ships belonging to America. I may here premise that many imbecile rulers find that the disturbing influence of a few designing jesuits is an overmatch for their knowledge of government, so cut the knot instead of untying it, by prohibiting the order of jesuits entry into their country; but as our patronage or hereditary system of government cannot retard the improvement in Marine Architecture which is being made in free America, or prevent superiority obtaining its reward, viz. a monopoly of the carrying trade of the world, our nautical patriots should at least urge the nation to free our seamen of the dread of impressment, the better to cultivate the nautical genius of the nation.

To a maritime nation like Great Britain, the debasement of the moral and intellectual condition of its seamen not merely places its politicial condition in great jeopardy, by provoking unprincipled seamen to sail away with a fleet, but retards the discovery of a sound theory of ship building, so that policy and philanthropy point to the advantage of improving and increasing the number of practical naval architects from the class of experienced seamen to improve that noble and useful machine, a ship. For when the principles of this science be known, the arrangements of the parts of a ship may be altered to suit the application of a general principle to a peculiar form. Rome, when the mistress of the world, found herself unable to cope with the ruler of Britain, Caius Cacausius, when he became independently possessed of a navy; and here, continues the historian Charmack, page 225, "even through the mist of antiquity do we discern as clearly as at the present hour, that great principle of national defence, on which Britain founds her proud superiority, a principle which nature has disdinctly ordained, and which, in common with the rest of her ordinations, is immutable." A very little reflection must convince the amateur statesman, that the rise and fall of the rulers of the commercial world is involved in the philosophy of political economy, and also that nautical economy must be based on a sound theory of ship building, and that of moral seamen, in order to secure the carrying trade to Great Britain, or to secure the sovereignty of the seas, or to protect Ireland from invasion; for if our steamers cannot overtake the enemy's steamers, we may be invaded in despite of the bravery and loyalty of our seamen.

The qualities and properties of vessels are very much influenced by the material of which they are built. A vessel if of light materials, and being pliable, will sail faster and be a better sea boat than another similar ship built of heavy materials. Again, a stiff ship, every thing else being the same, will sail faster by the wind than a tender ship. On this account a vessel having bilge water, every thing else being the same, will not sail so fast as a tight vessel. In smooth water the speed of a vessel is governed by powerful sails more than by the form of the vessel. Nothing retards the discovery of the true principles of Marine Architecture so much as the gratuitous assumption that naval officers possess a scientific knowledge of seamanship, implied by the impolitic custom of designating our experienced practical seamen as common sailors, and our ship captains as masters, while our merchant ships are prohibited from wearing our national flag. The abolition of the school for naval architecture removed an incubus from the efforts of the practitioners.

There is no machine which involves so much knowledge in its design, construction and management, as that of a safe sea boat; when, therefore, we reflect on the cost, on the nobleness, or on its national utility, it must appear unaccountable that the maritime world is yet without a sound theory on the elements of design, or principles of marine architecture, while the utility of such a theory to instruct the designer is self evident.

Ships are to trade and commerce, that which the free press and education are to freedom; withal, our ships constitute the bond which holds our commercial and colonial empire together; and besides, they make our seamen, who again are the saviours of our maritime empire; in addition to which, they facilitate the arts of peace, the habits of industry, and accelerate civilization.

It is only now that the practical sailor is beginning to discover that draftsmen have not advanced the art of ship building one step beyond practice. The fact that vessels of every country have a peculiar form and widely different dimensions, from the flying proa to the Irish hooker, and yet possess superior sailing qualities, proves, if proof be wanting, the absence of a sound theory of design. It must not be overlooked that the expense attending a series of experimental mercantile vessels, nay the expense to obtain any peculiar draft, operates as a barrier to prevent the practical seaman from embodying or from giving public expression to his ideas on the best form of a safe sea boat.

Judging by the results of the many experimental vessels of war, and by the various alterations made in their dimensions and forms, the scientific world must now be aware of the difficulties which surround this science. They may furthermore agree with me, that it remains with the practical seaman to work out a theory for the use and benefit of the naval architect. Wherefore, the nation, not merely disregarded nautical education and experience, but it destroyed the intellectual force of our seamen by suffering our press masters to treat them as mercenary slaves.

I cite the rule for masting, taken from Loyd's book, as an instance or proof of our ignorance in the science of naval architecture, viz. "the length of the lower decks and the midships inside breadth added together, the half is the length of the mainmast." The least reflection, however, will establish the unsoundness of the above rule, inasmuch as two vessels, of the same breadth of beam, may have twenty-five feet difference in the length of the lower deck. A long vessel of twenty-five feet beam, may be four and a half times her breadth on the lower deck, whereas a short ship, of the same beam, will have three and a half times her breadth on the lower deck.

The rule for forming the main body plan, which is the basis of the stability and the good qualities of a safe sea boat, is yet more arbitrary; when, however, the wide difference between the Great Harry and the Great Britain be considered and that these vast improvements are the result of practice, it may be conceived that when a sound theory is established, that Marine Architecture may reach a much higher degree of perfection; more especially when we reflect on the great improvements in our mercantile navy, after the present mode of admeasuring vessels was established. Whatever facilitates the experimenter to embody the result of his ideas and experience, or even his opinions, will accelerate the production of a sound theory to assist the designer, just as the discovery of the art of printing facilitated the improvement in language by accelerating the discovery of the principles of grammar. I may here premise, that a sculptor, or a painter, may copy to perfection, yet be utterly ignorant of the secret laws of nature. Again, a good musician, however competent to copy music, may be incompetent to compose; an experienced draftsman may be utterly ignorant of the principles upon which an original design of a safe sea boat should be based.

The thoughtless *croakers* apprehend that our free trade government has neglected its first duty, viz: "the greatest good of the largest number for the longest period of time," by the repeal of the navigation laws. These short sighted croakers presuppose, firstly, that it is good policy to remain wilfully blind to the decline of our trade and commerce and national maritime character, without making an effort to apply a remedial preventive; secondly, that it is injurious to our manufactures to supply the raw material, cheap and quick, by means of cheap ships and cheap freight; thirdly, that our ships are perfect, and cannot be built cheaper, and that the designers of ships possess a scientific knowledge of ship building. Whereas, not until millions of the public money had been wasted in experimental vessels, could the public conceive the state of ignorance of our draftsmen and ship builders concerning the principles of Marine

Architecture, or the elements of design. It was perhaps to prevent the student from the necessity of having to unlearn certain theories, adverse to practical improvement, and which have been found unsound in practice, that government wisely abolished the school of naval architecture. Be this as it may, a sound theory of design must emanate from seamen, those whom the nation has heretofore held in mental and physical thraldom. Not until the Turkish fleet sailed away with the fleet, did we apprehend the danger to the state during war, arising from the custom of demoralizing our seamen by impressment. Until the navigation laws are repealed nautical knowledge and the value of moral seamen to the state would remain apparently unthought of or unknown. It deserves remark, that while the old and preposterous mode of admeasuring our ships for their register tonnage existed, our ship builders and draftsmen retrograded in the science or design of ship building; but since that period, our first class merchant ships have, by force of practice, so far improved that many of them out-sail our ships of war. Again, until the Company lost the monoply of their trade, the freights home on the Company's ships were seldom less then £25 per ton; whereas, our first class merchant ships of 1000 to 1200 tons, owing to being navigated upon more economical principles, and by performing their voyages in a shorter time, find that £5 is a remunerating freight. On similar principles of free competition, the government of India could be conducted with the like economical results to the state, after the expiration of the Company's charter.

It was the wants of artificial society that demonstrated the value of time, when forthwith the iron rail road was the result, and it requires no great prophetic gift, to fortel that as our knowledge in the elements of design improves, iron ships will be so formed as to surpass in cheapness and velocity our first class merchant ships.

The following sheets are not intended to instruct the practical shipwright, nor practical draftsman, but are addressed to those who are interested in the design of a vessel. My object is, therefore, to aid the experimenter and observant sailor to reconcile cause and effect, and the action and performance of vessels under various circumstances at sea, so as to facilitate, by affording to the original designer the requisite explanation, on the causes or principles which may influence the design. With regard to the impulsion of fluids, the foundation of the science of seamanship, I may premise, that, notwithstanding we know the fact that one large sail possesses greater impelling power than the same number of yards of canvas divided into a number of smaller sails, yet we are in want of a theory to account for this on scientific principles.

Again, the wands of a wind-mill acquire greater velocity, placed at an angle of 70 degrees with the wind, than when placed at an angle of 30 degrees; whereas, the yards or sails of a ship, sailing with the wind on the beam, act with greater propelling power placed at an angle of 30 degrees, than when placed at 70 degrees. Again, some vessels sail within four points of the wind, and some paper kites ascend to within 30 degrees of the zenith, that is, approach the point of repulsion. Again, seamen know that a vessel flies up into the wind as the breeze increases, thereby indicating the existence of another force independent of the force arising from the wind striking the sails. Again, two vessels, being near each other in a calm, will come in collision. This arises from the motion of the vessels and of the sails, demonstrating that the intermedium is deprived of its elasticity or vitality by exhaustion, whereby the external or exterior atmosphere presses the two vessels into such space where the air had lost its elasticity. Again, it is perhaps owing to the exclusion of the air from semi-fluids, such as pitch, &c. whereby the lightest bodies sink below the surface. A steamer frequently neutralizes or becalms the sail, occasioned by the speed generated by steam. I therefore infer the existence of a force before the sails, by means of their generating a vacuum by intercepting the passing current. Be this as it may, the very fact of our being without a sound theory on seamanship is itself a proof of the absence of a sound theory on the sister art of ship building; consequently, when theorists assert that the principles upon which the essential properties of ships depend being familiar to the instructed naval architect, such assertion is deceptive and erroneous. On the other hand, considering how much the excite-ment of emulation is deadened in the mere copyist, it may be conceived that the dread of having to unlearn that which we had acquired, would be a complete bar to all improvement; hence the object of these sheets is merely to encourage and to aid the observant sailors to communicate, collect, or concentrate their collected nautical experience, with the view to work out a sound theory of ship building for the use of the naval architect.

A community is a moral machine, of which government is the motive power, and man, from being an imitative animal, is what his rulers and pastors had made him. Leaving to others to trace the cause of our system of naval patronage, I fearlessly assert that one of the effects is that of giving to the false theorist a mastery over nautical experience and nautical thought, to the prejudice of seamanship and ship building, to the endangerment of the state, a catastrophe which can be alone averted by the collective experience of the commercial and nautical classes of the community advocating a cheap self government, the better to reward merit and foster nautical talent. I may here cite a paragraph of my letter to British ship owners in June, 1846, viz: Besides pen-
" sioning the old school naval officers, they should
" have the privilege to give a British register to any
" foreign built ship, of which they are owner. Every
" merchant ship is a national nautical school. In
" teaching practical seamanship to others, we train
" and teach ourselves the science of nautical adapt-
" ation; besides, it is owing to the absence of nautical

"ship owners, that the art of ship building has not
"yet worked out a sound theory.

"I may, in passing, observe, that the true test of
"a merchant ship is to sail and steer before a storm
"while laded; while the criterion is, yards of canvas
"to tonnage. The British ship owners, by having
"cheap ships, would be better able to drive foreigners out of the market by open competition, but it is
"by our seamen alone with which our colonial empire
"can be held together."

Government, by the repeal of the navigation laws, has wisely anticipated events. The ship owners are thereby enabled to procure cheap ships, and besides, the force of competition, arising from the repeal of the navigation laws, will tend to improve ship building all over the world. In support of this assertion, I may observe, that the new mode of admeasuring our ships for register, has not merely rendered our first class merchant ships equal to men of war, but it has been the means of a new school being introduced in the proportions, dimension and forms of our merchant ships, to wit, firstly, greater length to breadth and less depth is now given on principle; secondly, a raking and a flaring bow; thirdly, the lower water lines are less concave; it therefore requires no great prophetic gift to fortel that the repeal of the navigation laws will induce many practical naval architects, with a spirit of enterprise equal to the Americans, to improve our merchant ships by building experimental vessels of the lightest material. On the other hand, it is to be hoped, that the government so far from tolerating a tax on the materials of which our ships are built, (I have now in my eye the tax on ship building timber at this port,) may give a bounty to ship owners, in the shape of diminished premiums of insurance on the blocks of approved ships, for which purpose, as I before observed, there should be a government insurance office. Great Britain cannot have too many merchant ships, or give employment to too many seamen or shipwrights, to enable our enterprising ship owners to compete for the carrying trade of the world; for which purpose they require cheap, fast sailing, capacious, safe sea boats. Withal, on the score of economy, the crew must be moral and intelligent. All restrictions on ship building are so many shackles on the spirit of nautical enterprize, while all restrictive laws not merely produce a state of apathy and discontent, but obstruct the improvement and cultivation in the art of ship building. Whatever contributes to make ships dear, gives to the capitalist a monoploy, to the exclusion of the experienced sailor or laborer. Hereafter, however, as the restriction are removed from the ship owner, and competition increases, the materials of which ships are manufactured will be conveyed to the mother country at a proportional cheaper rate of freight, to produce cheaper ships, while cheap ships will bring much dormant nautical talent into play, to improve the art of designing a safe sea boat. I am convinced that the repeal of the navigation laws will tend to elevate the art of ship building into a science, and thereby emancipate it from the influence of theorists, who, in respect of the elements of design, have much to unlearn. While the political economist, to whom the well working of the free trade principle is known, and to whom is known the good effects of that incitement and incentive to improvement which free competition produces in manufactured articles, and in mind, and in morals, cannot fail to perceive that the repeal of the impress custom or laws must tend to improve our seamen and our national art of ship building.

Whatever checks free competition, distracts the well working of the merit rewarding principle. The compulsatory clause, for instance, in the new act, obliging ships to have one man to twenty tons, is an injurious intermeddling on the part of the legislative power. Let us carry out the principle to riggers, by compelling the master rigger to supply the same number to rig or unrig vessels; when we should destroy that incentive to emulation growing out of innate respect for superior skill. Seamen are not mere machines, the skilful require not only forethought, but acquire presence of mind in the greatest danger.

Whatever increases the expense attending shipbuilding, retards the developement of the principles of the science by checking competition. Joiner's work on the frames of ships, for instance, is a useless expense—a misapplication of labor and of art, and tends to obstruct the discovery of the principles of the science. Polished marble would make the sides of a water drain, but rough rock stone answers the same purpose. Again, a granite bridge would answer for a rail-road to pass over better than that of a temporary wooden bridge, but if stone bridges were to be built, there would be no funds remaining to build the rail-road. Those executive officers who are most ignorant of useful principles, make a show of architectural elegance, or great finesse to conceal the narrow rules of art by which they are guided.

Of the impolicy on the part of the first maritime power to omit to concentrate and record the nautical knowledge of our unlettered seamen, which bears upon naval architecture, there can be but one opinion. The preceding remarks are intended to notify or direct public attention to the cause as well as the consequences of the past decadency in nautical genius. How far I may have succeeded in suggesting the ways and means to work out a remedial preventive against past errors, remains for the nautical reader to determine. Meanwhile, however, I trust that the men of science may be induced to examine what I herein offer as a basis for a theory to encourage others to offer their theories, by which to elevate the art of ship building into a science. Cobbet truly says, that "an ounce of principle is worth a ton of rule." A knowledge of the elements of resistance and impulsion of fluids, or even a knowledge of certain facts or effects of fluids on floating bodies, will assist the amateur designer to have some knowledge of the principles of naval architecture, to enable him to apply such principles to vessels intended for different purposes; to wit, a vessel to navigate in smooth water, requires a different form to one intended for sea. A vessel to be impelled by steam, requires less stability than a vessel to be propelled by wind. A capacious strong vessel requires a different form to one intended only for speed. Besides, a knowledge of these general principles will prevent the designer from suffering a supposed curve of beauty in the quarter frames in the after body to force concave water lines, as this would be an unnecessary sacrifice of the utility and symmetry of the whole machine, either to please the eye of the artist while in the act of forming the plan of a part, or to oblige or accommodate the practical shipwright. It is in this manner that the science of naval architecture has been kept in the back ground, by prejudice, caprice, ignorance, and convenience.

Power, like pleasure, when pushed too for, destroys itself, re-action being equal to action. Instance our tea tax on America, or the holy inquisition, or our impress system. If naval despotism, or imperial indulgence, be a sign of common sense, in that case the hog, which indulges its propensities by wallowing in the mire, possesses the highest degree of common sense; but as restraint, and not indulgence, is virtue, it follows that that community which imposes or applies the will of the people on the executive as a restraining power, exhibits most virtue and most common sense. A community to benefit by its own collective talent, must be taught self government, just as children are taught the four rules of arithmetic. The first lesson consists in the annual election of jurymen; the next, to set on thejury; in all civil cases, three jurymen to suffice, and if one of them agree with the judge, that to be the decision of the court.

No service is a better test of nautical superiority than that of the whaling trade. It tests the qualities of the ships and boats, as well as the sinews and physical and moral courage of the seamen, and consequently it is a good nursery for men-of-war seamen. (I write from practical experience.) The south sea whaling trade is nearly monopolized by America. It remunerates their nautical owners, but cannot remunerate our unnautical owners.

The fact that American merchant ships are navigated by a less number of seamen than that of other ships, is also an argument in favor of America. A system which improves their seamen, necessarily improves marine architecture, and *vice versa.* As, however, the bare apprehension of nautical inferiority would have an injurious tendency, our power and ability to retain the carrying trade and the sovereignty of the seas must be above suspicion. It is too late to lock the door after the horse is stolen. It will be too late to remember that steamer seamen do not require the same training as sailors of old, and that therefore superiority in ships will hereafter tell against us to a much greater degree than heretofore. The result of the Spanish Armada affords no argument as to the result, should despotic Europe, envious of our riches, resolve on our subjugation.

Notwithstanding that the Chinese have built vessels for many centuries, yet the art of ship building in China remains stationary. The cause of this is obvious. Paternal despotism has prostrated the intellect of the Chinese to that standard of subserviency most agreeable to the tyrant, while custom prescribes the form and proportions of vessels to prevent its developement. How, it may be asked, are the Chinese to elevate that art into a science? So long, therefore, as custom holds the mind of that nation in thraldom, it is absurd to expect that the speculative theorists can instruct the experimenter, or that the practitioner can work out the hidden principles of design to enlighten the man of science. On the other hand, if professional pride upheld the belief that ship building was perfect, or if the theorists believed that their preconceived theories are based on principle, because, forsooth, *their* practice accorded with *their* theory, in either case they would resemble blind men in the dark, grouping their way through an endless labyrinth.

The object of despotism is to make ignorance bliss. A people that are deadened to a sense of the inestimable value of self government, would be content with having their wives from a seraglio. The evil influence of despotism on the mind and character of the nation destroys itself by reaction. The Company, for instance, with its opium monopoly, and milder system of despotism, accelerate the decline of the despot's power in China. A total disregard of the golden moral rule, with tact to work on the fears and feelings of a credulous confiding people, is the royal road to despotism. The history of Europe informs us that practical philosophers of Galileo's standard, were incarcerated for tasting the tree of knowledge. Happily for the human family the new world has whole nations of practical philosophers. America teaches not merely that freedom is the parent of sound knowledge and cheap government, but that freedom is the philosophy of the arts of peace, and the life of nautical improvement. Mind, like water when unobstructed, will find its own level, and even cultivate itself. The new energies and gigantic strides observable in the new world, prove that the tone of intelligence which freedom has there worked out may also demonstrate that the power of equity is divine power. The self governed citizens of America being, apprehensive that there lurked in free-masonry the germ of clan-ship or of passive obedience, resolved that no public servant should be a free-mason; on the other hand, the Catholic despots, apprehending that masonry lead to self government, prohibited masonic meetings. Let a special pleading judge throw the weight of his prejudices into the scale, and at the same time enlist his sympathies to lighten the other scale, when his imbecility makes the very worst enemy to the state. Injustice and despotism prevent the advance of good government just as despotism and ignorance obstruct the advance of naval science. Minds pent up by artificial means, thirst for new opinions, which again like rain drops accumulate into irresistable torrents to sweep before them mal-legistators and usurpers of other's rights. America seems to be teaching to the world some valuable lessons on the arts of peace, and at the same time is assisting to teach maritime Great Britain that the best proportions of vessels with which to work out the hidden theory of design, is six times the breadth for the length. Great Britain, on the other hand, by teaching to China a lesson on the art of war, proves to China that freedom is the life of the science of war. As education and intelligence spread, the evil of mal-administration is seen and felt, and the value of practical knowledge and science are appreciated by the people. Our Cape colonists, dreading to familiarize their posterity with the sight of convicts, are testing their moral force to prevent the Cape becoming a penal settlement. Perhaps the nauticals of Great Britain are beginning to suspect that our naval systems are antagonistical to the spirit of the times, and that our executive officers, especially the press master, are far below mediocrity, of which our want of knowledge of nautical sciences, and the danger of subjugation by France, as pointed out by Admiral Napier, are the effects and consequences.

It would seem by the appointment of the late survey, Capt. William Symons, R. N. and by the latitude given to that gentleman by the Board of Admiralty, that our naval organs of government had in regard to building our ships of war some doubts of their own abilities either as practical theorists or inventive practitioners. It is, however, not to be expected that our Board of Admiralty, any more than the Chinese authorities, would infringe on ancient limits, or dispute the authority of custom. Be this as it may, Capt. Symons proceeded on the principle that three times the breadth was the best proportion whereby to test his preconceived theory; vide H. M. S. Star, Vernon, Serpent, &c.

Such is the force of authority, that previous to the late surveyor's vessels having had a fair run in practice, to call in question the safe sea boat properties of vessels built on Capt. Symon's plan, was considered by many naval officers a crime against nautical science. It is difficult to convince men in authority of their own want of knowledge in an art, against their interest. They cannot, for instance, perceive the wide difference between two hostile fleets seeking to meet each other when the bull dog courage of our seamen overruled any superiority in the enemy's ships, and that of their steamers, having superior speed, landing an invading army in despite of our navy. Superior knowledge in nautical science is power. The statesman is known by the result. The tree is known by the fruit. It is to be hoped that the reports of the experiments which led to the abandonment of the late surveyor's plan have satisfied the organs of government that visionary theorists, as well as amateur seamen, are almost incompetent to qualify for experimenters to work out a theory of design. This then is removing one difficulty. A people which are kept in leading strings must sink in their own and in public esteem, and as a nation, would lose its station in the scale of nations. Again, if one nation surpasses another in its commercial appliances, to wit, its ships or its seamen, or even by freedom from taxes and other restrictions, or surpasses the other in moral and mental superiority, in that event its commerce, trade, industry, and revenue, would improve and increase, while in the other, poverty, misery, crime and anarchy, would be the result. Practical philosophers of all nations maintain not merely that honesty is the best policy for statesmen, but that honesty is the philosophy of a sound system of political economy, while injustice, similar to our impress system and usurpation of the public rights and overtaxation, produces a diseased mind, to lead to the decline and fall of the nation. For my part I have always considered that our system of naval patronage and impressment, have obstructed naval improvement almost as much as that of the Chinese system of paternal despotism and parental tyranny.

If there be one subject more national or more universal than another, the one under discussion is that subject. It is the life of our commerce and of our nation's greatness. So far from obstructing the advancement of nautical knowledge, which is the case of our system of patronage, every naval officer should be a practical sailor. So far from taxing the materials of which ships are built, as is the case in Maulmain, a premium should be annually given for the best new vessel of every class, open to all nations. No nation would benefit by the discovery of a sound theory more than maritime Great Britain, inasmuch as that discovery, by putting her on an equality in ships with other nations, would work out the hidden worth of our enterprising seamen and seafaring classes. When ships are equal, naval superiority will mainly rest on the superiority of seamen, so that the real question is, as to the effect which freedom may have on the morals and professional abilities of our brave and patriotic seamen. I consider the following to be a good test of the superiority of seamen, viz: the lowest rate of premium on ship and cargo, the ship having at the same time the least number of seamen to her tonnage. The cause of maritime superiority is the cause of freedom. That naval nation which takes the lead in the latter, is destined by nature to give the initiative to a maritime world in taste and in opinion.

Most of Harvey's contemporaries questioned the theory of the blood. Many of Dr. Esdale's contemporaries suffered their false pride or self interest to cause mesmerism to be received as a fiction, notwithstanding mesmerism is an established fact. It would be strange indeed if the proportions of vessels which I consider best adapted to work out the theory of design, viz: in length on deck six times the extreme breadth, be not questioned or condemned by amateur officers from the school of ready made officers.

It may deserve remark that the character of the government was not affected by the truth or otherwise of Harvey's theory of the blood, or of mesmerism, whereas in ship building, and in the alleged cause of our national ignorance in that art, we call in question the measures of previous governments, and perhaps national pride. Be this as it may, a just dread of our decline and fall, or of having our national fame in the cause of civilization eclipsed by America, may perhaps excite in the nation a jealous emulation in the cause of freedom. In that event it should begin with the emancipation of our seamen from the influence or dread which will ever haunt them in regard to the national custom of impressment, until government has denounced that custom. It is strange that no writer has ever fully pointed out the evil workings of our impress system, to the injury and prejudice of the science of ship building. Heretofore any defect in our ships during the war with France, when the hostile fleets met, was overlooked by the success won by the bull dog courage of our seamen. The advance, however, of steam and of science, render the bull dog courage of our seamen less valuable, and considering the great stake at risk, in the event of a continental war, it is therefore full time that the attention of the nation be riveted to the subject. There can be no doubt but we can successfully repel any French invasion; but the things which our government cannot repel, are the new energies and impetus which freedom gives to America in the arts of peace and in nautical scientific attainments, to improve their commerce through the medium of improving the ships and men belonging to their mercantile navy, to end in swamping the old European institutions.

If a part of a fly-wheel of a watch be magnetised, the works would be stopped. The patrons of our patronage system found the impress system a convenient instrument, the natural effects whereof are, firstly, the nautical talent and genius of the nation at the lowest ebb, of which the ship building and nautical knowledge of the Board of Admiralty is an instance; secondly, a settled aversion in our seamen to join the navy; and thirdly, our want of knowledge in the science of ship building; either of which are sufficient to insure the decline and fall of our maritime greatness. It is for the British nation to resolve whether or not it shall keep the lead in maritime affairs, or patiently witness a set of imbeciles, the victims of artificial society, causing its influence to decline.

Our naval legislators, who, ever since Charles II. impressed by proclamation, have not exhibited one redeeming feature save the intended repeal of the navigation laws. Those composing our Board of Admiralty require to be individually tested at our sea port towns by the merit rewarding principle. Partial interest must yield to a national good. Cheap ships are now a real state necessity, to secure the carrying trade, and as the ship builders and timber traders of Maulmain know too well that the Company's system of revenue and patronage are barriers to the manufacturing of cheap ships, this is one valid reason why the idea of granting a renewal of the charter should not be entertained by the nation.

Owing to the inability of the naval organs of government to remove the cause, which rendered our navy the aversion of our seamen, custom established the belief that impressment was an evil without a remedy. Even Junius was under the influence of this absurd belief; that is, ignorance in power succeeded or confounded effects with causes to pass off fiction for fact. Had the evil effects of this line of naval procedure been limited to the press masters and that of our man-of-war seamen, time would have worked out the best antidote for the evil by our powerful seamen taking justice to themselves; but since the evil effects of an inefficient Board of Admiralty are also the cause of our national ignorance in the science of ship building, which in the present day, from the facility with which superior steamers might land an invading army, in despite of the indomitable bull-dog courage of British seamen. But the avocation of jugglers would be gone, if their secret was known. On the same principle, when it be known to the nation that the management of our naval affairs cannot be in worse hands, confidence must be withdrawn. I repeat, that Admiral Napier deserves the thanks of the nation for attracting the attention of the public to the fatal consequences of our remaining ignorant of our state of ignorance in the science of ship building; and the free press must excite public opinion and public attention to this important subject, that in our continuing wilfully blind to the fact that learned scientific pretenders find it to be their interest to mystify the ignorant and credulous, to conceal their own ignorance of the science of naval architecture, and of their inability to make our navy the ambition of our best seamen, we accelerate the decline of our naval greatness.

The sextant now used for measuring lunar distances, implies or presupposes a knowledge of the principles of astronomy; but as long as that degree of ignorance prevailed which caused Galileo to be incarcerated, because he determined that the sun was the centre of our system, neither the principles of astronomy, nor the improved sextant would have been known. In this case the whole circle of arts and sciences which were depending on astronomy, navigation and mathematics, for improvement, were obstructed by the jealousy and ignorance of traders in religion. Genius and science cannot flourish without civil liberty, that is, mental freedom, to keep wolves out of the pale of the government and from influencing a venal press. On similar principles, so long as impressment is considered a national evil without a remedy, Great Britain must remain comparatively stationary in the art of naval government, and in the art of ship building. The history of the mutiny of the Nore, and the death of Parker, for his efforts to clear away the weeds to allow a nautical genius of a Galileo to come forth, tend to illustrate the cause of our want of knowledge in the nautical sciences.

A ship in motion is influenced not merely by the composition of forces, in which by the way the laws of mechanics, and laws of resistance, and laws of impulsion of fluids, all amalgamate, but by the power of the void; no matter how a void or minus pressure be generated, whether by condensation, similar to steam in a piston, or by exhaustion, similar to that in the tube belonging to the atmospheric rail road, or by interception, as by the sails of a mill or ships, or by the velocity of a body passing through a fluid; nevertheless, the power of such void or minus pressure is the same. A knowledge of the principles of science is to ship building that which freedom, emulation, and ambition are to mental and moral improvement: we do not require to know the secret laws of nature to account for our peculiar taste, our senses, or the power of our imagination, seeing that nature has made them perfect; nevertheless, in the art of ship building, first principles are indispensible to improve in that art. To copy from others, is to be self-doomed to become a second rate naval power.

In general prophets are not known in their own village. This may arise from the powers that be disliking collision of opinion, or from a dread of the reformer disturbing existing things; or it may arise from class interest, clanship, or partizanship. Be this as it may, the incompetent dread the vote by ballot, and the abolition of flogging in the navy, because it might exhibit their unfitness by non-election, or might even eclipse their clan or class by removing the prejudice from the unlettered nautical genius, in our mercantile navy. Logic, by skilfully using analogy and inference, aided by the imagination, or by the fears of the credulous, made *impressment* essential to *secure* liberty; made spies, patriots; made a horse chesnut, a chesnut horse; and burned those of common sense for witches or wizards. When igorance is in power, it siezes every place of debateable ground. Naval despots persuade the legislature that because our brave and patriotic seamen will not join the navy, therefore they must be impressed; meanwhile, our naval despots overlook the fact that America may checkmate us by her nautical improvements, or swamp us by her system of free government.

The British statesman who hopes to acquire posthumous fame, must improve our naval power by a change of men, measures, and principles, in order to improve the arts of peace; our seamen and our ships, seeing that the American merchant ships, of the class of the Sea Witch, are not only superior in point of velocity, but are navigated with fewer and therefore better seamen than our's.

Having in the preceding pages endeavoured to trace our ignorance of the nautical sciences to naval patronage and impressment, I may here premise that the highest order of learning, (and the community is bound to patronise the highest,) and that which is most beneficial to the community and to individuals thereof, is that of *self government.* Self government is, "LOVE YOUR NEIGHBOR!"—principle in practice. It elevates the mind and tone of public morals, and of public learning. It is the best antidote and remedial preventive to the mind.

The Board of Admiralty must be judged by the result. It is the result of any deteriorating system which proves the existence of adequate causes to produce a national catastrophe, like that of our inefficiency in ship building. It is during the transition state that the dupes mystify the victims, and the victims hug their chains. Witness our press master system; witness every where the effect and re-action of priest-craft and king-craft. By destroying the spirit of emulation in our seamen, the nation must sink in its own and in the world's esteem. Our system of naval patronage taints the blood of the press-master, while in respect to our practical seamen, it keeps them in leading strings, it weakens their mind, their loyalty, and their love of country, to end in undermining or destroying the ship building genius and character of the nation. If Englishmen hope to maintain their maritime superiority, our naval department at least must cease to be a pensionary or a hot bed of patronage. Nations, like certain animals, must shake off their cumbersome incrustations. Among other incrustations on ancient government, are our systems of patronage and hereditary legislation.

CHAPTER I.

Of the Laws of Fluids, particularly Water.

1st. "Water presses with equal force in every "direction," and its degree of pressure is in proportion to the distance from its surface.

The great Dr. Halley says, "That the pressure of "the water at thirty-three feet, pressed the natural "air into half its space in his diving-bell;" and by many experiments made by Captain Hutchinson, it appears, that "the pressure of water upon bottles of "different shapes, corked up with nothing in them "but common air, was as follows:—Two common "square flat-sided bottles which would hold three "half pints each, broke at the depth of between six "and seven fathoms; but two oval formed Florence "flasks, of nearly the same size, bore the pressure "to about fifteen fathoms. A round common quart "bottle broke only at about twenty-eight fathoms. "It seems, at a great depth, few things that are made "hollow and tight, will bear the water's pressure: "an instance of which has been seen by a ship that

" drove off the bank in Gibraltar Bay, into water so
" deep, that the anchor would not reach the ground
" at a hundred fathoms; and when hove up, it was
" found that two new nun-buoys had their sides
" crushed inwards by the water's pressure."

In a semi-fluid, such as pitch, mud, &c. &c., light bodies sink below the surface. On the other hand, a dead whale which had instantly sunk, is, when brought near the surface, raised with greater facility, thereby indicating that the absence of air in the semi-fluid may occasion the light bodies to sink, while the presence of air at the water's surface may be greater, to give expansion and therefore buoyancy to the whale. It is possible that the air which may be caused to mingle with the water, (by a raking bow,) indicated by air bubbles, may, by some chemical action, facilitate the water' keeping in contact with the after body to accelerate velocity. (The better the vacuum, the greater its power, and *vice versa.*)

2dly. "All floating bodies displace as much water as is equal to their weight," and are subject to the same laws as the quantity of water would have been which such bodies have displaced.

Fill any vessel with water, and place it in a scale with an equal weight in the opposite scale, then place any floating body in the water, and it will be seen to displace a quantity of water equal to its weight.

Place models of different shapes (from the wedge to the wedge reversed) in a line abreast of each other, in a stream that runs to a waterfall, and they will be seen not only to descend with the stream, and form every curvature with the eddy water, but they will be seen to fall in rotation, according to the fullness of the advanced end or bow, and this because of the greater quantity of water displaced by the advanced end.

3rdly. Water runs to its level, or into a vacuum, at a determined velocity, according to the pressure of the surrounding fluid.

All fluids possess a natural velocity, according to their density or cohesion. This will be seen, by pouring several fluids of different densities down an inclined plane at the same instant; suppose tar, oil, molasses, water, &c. when the fluid which possesses the greatest degree of cohesion, adhesion, or attraction, will be seen to run with the least velocity. The adhesive power of water is evident, by the quantity that may be dropped into a glass, after the water is level with the rim of the glass; and again, by the number of small particles of rain that compose a large drop, before the latter descends from any intercepting body: on this principle the phenomenon is accounted for, of the water being several inches above the (quarter) gunwale of a boat, when towed quickly through the water by a whale, &c.

Drop a piece of solid metal into a quantity of metal in a state of fusion, or into any fluid, and it will be seen that the vacuum thus created will require a greater or lesser time to fill, according to the density or adhesion of such fluid.

The natural flow of water is seen in every aqueduct, and is farther evinced by alternately raising the end of a tube or trough containing water. This natural flow is manifest in every river:—at the mouth of Rangoon river, where the tide rises upwards of 20 feet, it is there high water at 3 o'clock; while at Panlang, about 80 miles up the river, it is then low water, and *vice versa.* The mean velocity of the tide in this river during the year, may be estimated at three to four miles per hour; and by taking this river as a criterion, we may estimate the natural flow of water at three to four miles per hour.

4thly. The vacuum made by a body passing quickly through a fluid, is in proportion to the density of the fluid, to the velocity with which it is passed through it, and to the fullness or squareness of the hindermost end of such body.

Move a wedge, for example, through tar or oil, with the small end foremost, at the rate of three miles an hour, or three and half feet per second, and there will be seen a large vacuum behind: reverse the wedge, and move it with its large end foremost, at the same rate, when little or no vacuum will be seen. A vacuum is seen behind a ship's rudder, when sailing fast; also behind a boat's oar, in the act of being pulled strong. In fact, a vacuum is made by passing your hand flatways through water, or a tea-spoon through a cup of tea, but much more so through a more dense fluid.

5thly. All bodies specifically heavier than water, descend to a point where the upward pressure of the water is equal to their weight.

This is demonstrated in the act of sounding in deep water, when the person that holds the line supposes the lead to be at the bottom, when no bottom is to be ſound; again, by the decreasing rate at which the deep sea lead descends; and may be seen by the distance which pieces of wax, made specifically heavier than water, will be suspended below the surface of a glass of water.

CHAPTER II.

Of the Resistance of Fluids.

" The theory of resistance is a subject which has " exercised the extraordinary talents of the most " distinguished mathematicians of the last century. " Nevertheless, it is a subject which is as yet very " imperfectly known. It seems that Sir Isaac Newton was the first who attempted to make the motion " and actions of fluids the subject of mathematical " discussion; yet even he, with all his genius and all " his science, was at length convinced that it was in " vain to expect an accurate investigation of the motions and actions of fluids, where millions of unseen " particles combine their influence, &c. He, however, figured in his mind an hypothetical theory; " and from this hypothesis deduced a series of propositions, which formed the basis of all the theories " of the impulse and resistance of fluids that have " been offered to the public since his time.

" From these theories the following principles were " deduced, as the laws of the resistance of fluids: we

" give them here, in order to shew how far they have " been found to agree with actual experiments, in " what respects they differ, and to prevent the young " artist from retaining those erroneous ideas of the " subject which he perhaps may have already acquired."

1st. " The resistance, and (by the laws of motion) " the impulsion, of fluids on similar bodies are pro" portional to the surfaces of the solid bodies to the " densities of the fluids and to the square of the velo" cities jointly..

2dly. " The direct impulse of a fluid on a plain " surface is to its oblique impulse, as the square of " the radius is to the square of the sine of the angle " of incidence."

3dly. " The direct impulse on any surface is to " the oblique impulse on the same surface, as the " cube of radius to the solid which has for its base " the square of the angle of incidence, and the sine " of obliquity for its height.

4thly. " The direct impulse of a fluid whose " breadth is given, is to its oblique effective impulse " in the direction of the stream, as the square of ra" dius to the square of the sine of the angle of in" cidence."

" The numerous experiments with which these " propositions have been compared, have most de" cidedly proved that they are, with the exception " of the first, exceedingly erroneous; and even that " is not in all cases correct."*

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* Steel's Marine Architecture.

The translator of Chapman's celebrated work on Marine Architecture there states:—

"That Chapman's theory of resistance to ships "cannot be depended on, as leading to true results, "inasmuch as he admits into it two suppositions "which have been repeatedly proved by experiments "to be false.

"In his interesting experiments printed at Stock-"holm in 1795, he endeavours to substitute another "theory in the place of the one given in his Marine "Architecture.

"It is to experiment, and perhaps to experiment "alone, that we are to look for the basis of a true "theory of resistance and impulsion."

Water being the foundation and life, as it were, of Marine Architecture, it is hence manifest, without a true theory of the resistance of water, the true theory of Marine Architecture can never be discovered.

The resistance of fluids is in proportion to their density, cohesion, adhesion, or attraction.

The opposition which any body meets in its passage through water arises,—

1st. From the cohesion or *vis inertiæ* of the water.

2dly. From the adherence of the water to such body, or the friction; and,

3dly. From the retractive power of the vacuum created by a body passing quickly through the water.

The natural flow of water being taken at three to four miles per hour, at the same time bearing in mind that water flows into a vacuum from every direction, it is therefore obvious that when bodies are moved slowly through the water, say six miles per hour, the water is enabled to keep in contact with the hindermost end of such bodies by virtue of its natural flow, in which case there is no vacuum; consequently, such bodies are resisted by the "*vis inertiæ*" and the friction of the water only.

Upon this principle the phenomenon is explained, which is witnessed in every large fleet, namely, that full-built ships frequently outsail our finest ships in light winds and smooth water.

Owing to the experiments of M. De Romme not being made with sufficient velocity, he "found that "bodies advance with the same celerity when drawn "by the head end as when drawn by the stern end;" of course that it was indifferent which end moved foremost.

Even the square formed sailing barges in London river will, in a fresh breeze and smooth water, exceed six miles an hour, whereas our finest sailing ships will rarely exceed four miles in a seaway, sailing close to the wind. In fact, in strong riplings the head way and steerage way of a vessel is almost stopped. The motion of a ship creates a vacuum about the after body, which tends to retard its advancement.

In smooth water the ship is the agent acting, whereas in a violent sea, the sea is the agent acting, and the ship the agent acted on. Boats in a high surf are thrown about almost like shuttle cocks; meanwhile the pitching, or rolling motion of a vessel is again affected by her dimensions and form, or position of the centre of displacement. In regard to the disturbing forces of the potent and varied agencies of the sea, and in regard to the leverage power which great breadth presents to be acted upon by the sea, we have only to conceive a pair of well adjusted scales and a pair of steel yards to be suspended on the same centre line, and one of the scales and the long arm of the lever to be acted upon by a vertical column of steam, in order to conceive the power of impulsion, or vertical effort of the sea on a ship. The difficulty in calculating the force of a hammer striking a nail, more especially when some divergency happens to the centre of metal, will illustrate the difficulty in calculating the vertical effort of the sea with any degree of exactness. Inability to calculate the force of the sea, like inability to explain the secrets of nature, cannot impugn the facts nor the principle, viz: that motion generates a vacuum to retard velocity.

The arms of the rower are relieved by the pliability of the oar—the back of the horse by the pliability of the shafts of the buggy—the shoulder of the cooly by the pliability of the bamboo, or stick with which he carries two heavily ladened baskets. The vibration of the arrow facilitates its flight, while pliability in the hull of the vessel facilitates velocity.

It is an undisputed fact, that a loose rickety vessel will sail much faster than when she is immoveably bound.

Hence it follows, to ascertain with precision the laws of resistance, so as to discover the comparative advantages arising from the form, either of the head end, or of the midship body, or of the stern end, of all kinds of navigable vessels by means of models, the experiments must be made in agitated water, and to be drawn through the water at the rate at which fast sailing vessels can sail, namely 10 to 15 miles per hour, or 20 to 25 feet per second. From these points being neglected by the Society for the Improvement of Marine Architecture, and other experimentalists, their experiments failed in determining the form of a vessel best adapted for velocity. Consequently seamen are now the only experimentalists to whom we are to look for true results respecting the laws of resistance and impulsion of water.

The nature of *vis inertiæ*, and the power requisite to overcome it, together with that of friction, having been so elaborately explained by the Society for the Improvement of Marine Architecture, very little remains to be said.

It may be proper, however, to remark, that the effect of friction diminishes when vessels obtain their greatest speed, which is proved by the rate at which wood bottom vessels sail in a fresh breeze.

In 1811, I commanded a Swedish built brig out of London, called the Louisa, not coppered, that sailed 9½ to 10½ miles per hour for several hours.

Every person that has walked in the water up to his waist, must be convinced of the remarkable fact, namely, that when he attempted to increase his speed through the water, then the resistance of the water increased in a double ratio.

The power of the water is incalculable.

" Place a ship in a dock, that is made to fit the
" exact shape of her bottom, leaving only the smallest
" space between the ship and the dock; fill that
" space with water, and the ship will be as effectually
" floated as if she were in the ocean.

The smallest vacuum between a vessel and the water will attract such vessel equally strong with the largest vacuum. Remove the water from one side of the dock, and the vessel will be as strongly attracted as if the whole side of the dock had been removed.

Water presses equally in every direction; if, therefore, the smallest vacuum were made in the water at any particular part of a vessel floating, the full force of a column of fluid would be immediately felt in a contrary direction, forcing the vessel into such vacuum.

A vacuum is seen on the opposite side of an erect post, in a stream of water against which the stream is running with great velocity; it is likewise seen behind any square body moved quickly through the water; behind a vessel's rudder, when sailing fast; by passing a spoon quickly through a cup of tea, or your hand flatways through the water. Witness the vacuum behind the buoys in the river Hoogly during the freshes.

The retractive power of a vacuum is evinced by the vibration of the rudder, and even the vibration of the after body of every vessel, when sailing at its utmost speed. It is confirmed by the practice of unloosening privateers, &c. to increase their velocity when closely pursued by an enemy; which is effected by rendering the vessel pliable, for when pliable she yields to the retraction of the vacuum under either quarter, and consequently is less forcibly retracted by the vacuum. This fact, however, is known to every person accustomed to boat sailing. I well remember having charge of a boat in the river Plate, which when loose and rickety, and so leaky as to require a man continually to bale her, then outsailed every boat; but after she was firmly bound, then every boat beat her.

The power of the vacuum is demonstrated by a spar or long piece of wood being plunged into the water in an oblique direction, when, notwithstanding the greater degree of upward pressure of the water on the lowest end of the spar to alter its line of direction, (which, admitting the spar to be 16 feet long, would be four times more affected by upward pressure of the water than the uppermost end,) yet the spar, or a boat-hook staff, will be seen to return in the precise direction in which it entered the water.

The power of the vacuum is again proved in the act of pumping quickly. The piston being raised faster than the water flows, or can follow the piston, a void or vacuum is created between the piston and the water, at which time the piston is forcibly retracted by the vacuum, until the water comes again in contact with the piston, when the pump makes a hollow sound, termed "striking" by seamen.

The retractive power of the vacuum retards descending bodies from reaching the bottom quickly.

A deep sea lead, for example, dropped from the forecastle of a ship 120 feet long, and she sailing at the rate of eight miles per hour, would not reach the bottom in 20 fathoms water, by the time the stern of the ship arrived at the spot where the lead entered the water; on this account pilots are obliged to reduce the rate of a vessel's sailing, when correct soundings are required in 20 fathoms.

Every person that has hauled in the log-ship with its pin in, and the ship sailing fast, must be convinced that it requires much greater power than would be requisite to haul in a fish of twice the thwartship size of the log-ship.

A floating anchor derives its power to hold a vessel from the retractive power of its vacuum. Upon the same principle, the droge of one foot square used by whalers to impede the velocity of whales, more effectually retards the whale than three boats, although the thwartship section of each boat with her crew and equipment must have two square feet immersed in the water. Again, when a dead whale is to be towed to the ship, it is towed with its head foremost; but when it is required to act as a floating anchor to a vessel, then the cable is fastened to the tail of the whale. Buoys which are moored in a strong tide way, require better mooring than that of a vessel with a long, clean, convex run, although the vessel may be fifty times larger than the buoy. For the same reason, a vessel with a fine lean bow, acquires much greater velocity in her stern boards than a vessel with a full bow.

The practical engineer knows that the better the vacuum, the greater its power, and vice versa; that is to say, a pump not air tight fails to generate a good vacuum. Generate a vacuum in a boiler, when on turning a cock which is below the water, air will rush into the boiler through the cock, instead of water running out thereof. It is the vacuum generated by the act of throwing the boy's top, which causes it to spin on its peg. On the same principle a marline spike falling from aloft, falls point downwards. A ship in the act ofsinking, creates a vortex dangerous for boats. A whale boat sinks by the stern when towed by a whale at a great velocity; onthe other hand a shot is made to duck and drake along the water by its resistance. Yet the cause of the eddies, or vortex, seen behind a ship proceeding at her utmost speed, and cause of motion, or rather the cause of resistance to velocity from motion is over looked. Instance the concave water lines in the steamer Franklin. Hollow water lines deprives the vessel of capacity and buoyancy without an increase of speed. If the designer were to order the launching ways to be laid with a curve downward, it would shock common sense, and the practical shipwright would naturally question that order. Yet hollow water lines are equally opposed to the good properties and qualities of a safe sea boat, as that of laying the ways with a curve downward would be to the act of launching. Again, instance the great breadth which the late surveyor gave to our ships of war. Motion retards velocity, and great breadth accelerates motion against a head sea.

The following experiments, however, will more effectually demonstrate the retractive power of the vacuum.

Have models of every kind of navigable vessels; let them be made hollow, having holes pierced through them in every part, and of the same specific gravity: place them with their stern ends in a line with each other in a stream of water, just above a waterfall, or near any vacuum in the water, and on their near approach to the waterfall or vacuum, it will be seen that those models which have the fullest runs, or in other words, which have their center of displacement nearest the stern end, will not only emit the greatest quantity of water through the hole in the stern and quarters, but will be the first precipitated or attracted into the vacuum; while those models whose centers of displacement were farthest from the vacuum, or nearest the head, will be the least attracted, and consequently the last precipitated down the waterfall.

If, then, equal weight had been fastened to the models, it is evident, that when their stern ends were at the brink of the waterfall, the weight which would be able to sustain from falling those models whose centers of displacement were farthest removed from the vacuum, would be inadequate to sustain those from falling whose centers of displacement were nearest the vacuum, and which were the first precipitated down the waterfall. And as it requires the same power to sustain any body immoveable in a stream of water, as to propel it through stagnant water at the rate at which the stream was running, it follows hence, that a vessel, whose center of displacement (every thing else being the same,) is the farthest removed from the stern, will obtain the greatest velocity with the propelling power; that is, the vessel with the longest run (every thing else being the same,) will sail the fastest.

Observations on Impulsion.

The impelling power of the following sea has more effect on a light vessel, than on one deeply ladened. It has also more effect on a short ship, than on a long ship, and on a full ship than that of a fine built ship. On the other hand, the resistance from the head sea is greater on a broad ship than on that of a narrower one. In the latter case, the ship is the agent acting against the head sea, whereas, in the former case, she is the agent acted on by the impulsive power of the sea.

While in command of the brig Bucephalus, and during a strong S. W. breeze, I endeavored to enter the river of Maulmain against a strong ebb tide, the vessel sailing at the rate of seven knots. I had two small jolly boats in tow, one had a long tow-rope from the cat head, the other a long tow-rope from the stern. The boat which was fast by the cat-head was impelled forward by the sea before the ship until checked by the tow-rope; at the same time the other boat was impelled forward by the sea, and sunk the other boat which was athwart the sea; the boatmen saved themselves at the fore-channels.

Considering the power of impulsion and vertical effort of the sea on a ship to neutralize and disturb the laws of mechanics, this consideration is an important element to be kept in view by the designer of a safe sea boat.

Observations on Attraction.

Such is the all-powerful influence of the vortex, vacuum, or minus pressure in fluids, no matter how it be created or generated, that it must be considered by the scientific as a universal law.

The better the vacuum, the stronger its attractive power; the larger the vacuum, proportionally greater its attractive power. For instance, a large ship with a heavy cargo, in the act of sinking, creates a more attractive vortex than that of a smaller vessel, with a cargo of less specific weight. To be convinced of the fact, viz: that the larger the vacuum, proportionally greater is its power, we have only to move our hand through the water, keeping the fingers open; and again, with our fingers closed together. If the droge used by whalers to retard the speed of whales, was made open, like a grating, its power would be diminished, though the superfices of the droge was not reduced. It is on this principle that one large sail is more powerful on a vessel, than would be the same quantity of canvas made into a number of smaller sail.

Two currents of air meeting occasion a whirling motion, which again creates a vortex, possessing a vertical attractive power, demonstrated in whirlwinds and water spouts.

Two currents of water meeting generate an eddy, or vortex, which engulphs bodies that are within its influence.

Boys oftentimes fail to spin their tops, owing to their inability to throw them with sufficient force to create a vortex, or miniature whirlwind.

The practice of wetting boats' sails, while sailing close by the wind, goes far to prove that by closing the pores of the sails, the power of the void or minus pressure before the sails, is thereby increased.

The pitching motion in a vessel creates a vortex to retard its progress.

Generate a vacuum on one side of an air balloon, when the pressure of the air on the opposite side would press the balloon into such vacuum.

Set an incumbustible sail close abaft the funnel of a steamer, when the power of the sail would be increased by the rarified state of the air occasioned by the heat of the funnel. It is in fact on the principle of the power of the void, or minus pressure before the sail, that the phenomenon of vessels sailing within four points of the wind is reconciled.

The capillary principle, for instance, is more active in one substance that in another. Place two glass tumblers near each other, one being full of water, the other empty; next put one end of a small strip of cotton, woollen, or cloth of horse hair in the full glass, the other end to be placed into the empty glass; when it will be seen that the water will in a short time become level in the two glasses, in a greater or less period, according to the nature of the fibre, or to the greater or less twist in the thread of the cloth. In the capillary process the void is self created to accelerate the water's ascent.

A full built vessel, in passing through water at her highest speed, say seven knots an hour, would create a larger vortex than a vessel with a fine run, sailing at the rate of ten knots.

In ship building the object is to facilitate the diminution of the vortex, all else being the same, to obtain speed, whereas, in seamanship, it is important to know how to increase the power of minus pressure, or vortex, before the sails, to increase the power of the sail, all else being the same.

CHAPTER III.

Observations, &c. on the Causes which produce, or which more or less affect, the primary Properties of Navigable Vessels.

A navigable vessel, to be a safe and perfect sea boat, must have velocity, buoyancy, stability, and sufficient strength to withstand the shock of wind and waves.

These primary properties embrace steering while scudding, lying too with safety, sailing fast by the wind, holding a good wind, staying and wearing promptly, riding easy at anchor, pitching and rolling, easy capacity, &c. &c.

Therefore, in the construction of a vessel intended to cross the sea, the first and primary consideration should be regarding her safety, and not respecting her capacity; or,

" That a ship with a certain draught of water, " should be able to contain and carry a determinate " lading." Thus encouraged to render a vessel capacious and burthensome by the most celebrated writer on marine architecture, it would be indeed extraordinary were ship-owners or ship-builders to sacrifice their interest in the construction of a vessel for her safety, when almost every vessel can be insured; and if lost, why, no loss to them. Not so, however, to the country to which the ship belongs. I conceive the safety of the crew to be of so much importance to a state, as to claim the attention of governments to the safety of all navigable vessels.

Overbuilt, capacious, burthensome vessels, were in the greatest repute with British ship-owners before the new mode for registering was enforced, which necessarily must have influenced ship-builders to build their vessels of that description and form; and vessels of this construction require extraordinary large rudders to steer them, even in a tide's way; whereas a small rudder is the index of a fast sailing safe sea boat. A custom, however preposterous, being once established, obtains concession by convention.

Of the many vessels lost from being unsafe at sea, few or none of the crew survive to give the melancholy account of the cause of their disaster.

In a cross turbulent sea, there is nothing more dangerous than a large rudder. I am convinced there are more vessels lost from having large rudders, than from every other cause. This must appear evident to every person, when the square stern and after body of a ship is duly considered.

First, the after body is unsupported by the water.

Secondly, the after part of the after body is composed of fashion pieces and dead wood.

And thirdly, the stern frame is erected on a transom, which transom is again supported by the stern post. Being thus constructed, it would be miraculous if the stern, the stern post and after body, should sustain the shock of the sea against a large rudder in a heavy gale uninjured or unshaken, when it frequently happens that two men at the wheel are found inadequate to sustain the shock of the sea against the rudder in a calm.

In October 1822, I commanded the ship Victory, of 700 tons: we experienced a very heavy gale in the Bay of Bengal; our tiller broke at the commencement of the gale. The force of the gale kept the ship on her beam ends. The lee sea not only washed our long-boat some feet forward, and the wedges out of the foremast, but the water went down the rudder case from the poop cabins. In the end, we had to cut away our main and mizen mast to prevent the ship from foundering.

In smooth water the augmentation of displacement is greater, by the heel over or inclination of a broad vessel, than that of a narrow vessel, consequently the stability of a broad vessel increases proportionally more in smooth water, with the angle of heel, than a narrow vessel;—whereas, in a sea way, the augmentation of displacement, which follows the shock from the vertical effort of the beam sea, or center of percussion, on the broad vessel, not only produces a much greater inclination, but the center of weight of the broad vessel would rise higher, and oscillate much more than the narrower vessel.

We know that a narrow canoe has no stability. The out rigger, however, by expanding the base of support, gives to the canoe the greatest stability, while the elasticity of the bamboo prevents the rolling motion.

A vessel with a round bottom longitudinally, similar to the Calcutta dingee, for instance, the extremes are an incumbent weight, to accelerate the pitching motion, similar to the rocking horse, on the principle of accelerative force, and that of the fly wheel; on the other hand, a vessel with a great gamber in the keel, or which droops at the two extremes, has less incumbent weight, (to accelerate the pitching motion,) from her extremes being more water borne. In fact, this sagging has expanded the longitudinal base of support—has raised the center of displacement, and has increased the weatherly quality, similar to that produced by adding a piece of false keel at the extremes.

A long entrance, with concave water lines, diminishes the buoyancy and capacity of the fore body; it also contracts the limits of the main body, or the after body; that is, it contracts the longitudinal base of support, and forces the center of displacement and center of weight, that is, the axis of pitching motion, nearer to midships, to accelerate the pitching motion. On the other hand, a bold gripe accelerates weatherlyness, to admit of a moderate full bow, so as to bring the center of displacement before the midships of the ship. An increase of gripe increases resistance to lee-way proportional as the center of lateral resistance is carried abaft the midships of the vessel. A raking bow, however, is indispensable to protect a large gripe from the cable, while riding weather tide. The plough-share reversed seems to point itself out as a model for a bow.

In 1848 Mr. Innes built for me a slight, fast pulling boat, between a whale boat and a gig. The keel rounded downward six inches, somewhat similar to the iron of a scate; the weight of the rowers being in midships, therefore the extremes became water borne. By the bottom of this boat rising from midships forward, this form predisposes the fore body to rise out of the water, on the principle which causes the oyster shell to duck and drake along the water. In regard to the tendency of the rising line of the after body, to prevent the boat pitching when the rowers apply their strength, I may premise that the settling of the whale boat by the stern, when towed fast by the whale, until the water is some inches above the gun whale, indicates that the after rising line will tend to keep the after body down, to prevent the fore body from pitching, much the same as the feather on the arrow, or whirl given to the rifle ball, prevents them deviating from a straight direction.

The above remarks may suggest some of the elements of design, with which the constructor must be thoroughly conversant, to avoid mistaking and confounding effects with causes; and may likewise indicate, that in order to work out a sound theory of design, by force of practice, to eclipse or withstand the inconclusive mechanical reasoning of the sanguine theorists, the nation should carry out a series of experiments on some fixed proportion of length to breadth. Such is the complex nature of the elements of design, that a vessel may by chance be perfect in her form, or in her proportions, or dimensions, and yet the why and wherefore may be beyond the comprehension of the designer.

Observations on the Center of Gravity.

The masoolah boat which encounters the sea in its most violent form, has, (when the crew are in the act of pulling,) its center of gravity some distance above the water line. This fact deserves the consideration of the learned amateur draftsmen, who, in their design of a safe sea boat, may start from a meta-center, inasmuch as this fact indicates that stability acquired from the form, is a more valuable element in the requisite stability of a safe sea boat, than stability from dead weight, or from proportional greater breadth.

It requires no calculation to prove, that by raising the floor of a vessel, and at the same time adding the amount taken from the bottom by the raising of the floors, to increase the breadth upwards from the floor-head to the load-water line, that in smooth water stability would be increased, to increase thereby the power of carrying larger sails; while the center of lateral resistance would, at the same time, be more depressed to diminish lee way; that is, the base of support would be increased at the center of displacement, and that center be raised, but which increase of breadth, in a violent sea, would be the cause of a destructive rolling motion, and of a violent pitching motion against a head sea.

A vessel for instance, made of gutta percha, with a flat broad floor, yet being so altered as to give the floors a rise of 45°, and at the same time to increase the breadth from the floor-head to the bends, would increase the base of support, and increase also the surface of lateral resistance; that is, it would increase stability from these two causes, but would not affect the center of gravity, nor the quantity of water displaced.

Two narrow canoes lashed together, have much greater stability than one large canoe of the same breadth. Witness the stacks of hay piled up on the boats in the river Hoogly, thereby exhibiting the centre of gravity to be far above the surface of the water; that is, the expansion of the base of support, mainly governs stability, and not the position of the center of gravity, nor center of vertical effort, nor that of the imaginary meta-center.

Observations, &c. on Stability.

A body floating freely and at rest, the resultant of the force of water on which it rests is the axis of inclination; a broad vessel raises its centre of displacement and its axis of inclination nearer the plane of the water line, and besides expands its base of support at the center of displacement.

With the heel or inclination of the vessel, the center of displacement, or axis of inclination, also moves with the degree of inclination, whereby the incumbent weight of the side raised increases with the distance from the fulcrum, or axis of inclination, so that in smooth water the wind is the agent acting, the masts of the ship the long arm of the lever, one side of the ship is the weight to be raised, the other the weight to be depressed, while the resultant of the vertical effort of the water is the fulcrum.

A masoolah boat, from having no floor timber, the planks which form her flat bottom being sowed together, the incumbent weight of its sides settles down until they become water-borne, consequently the center of the boat's bottom curves upwards, assimilating in some degree to the form of a double canoe. In this instance the base of support is expanded at the center of displacement, and greater stability obtained by raising the position of that center.

The bottom of the boat being curved upwards, is kept in that position by the pressure of the water against the sides of the boat, and which pressure at the sides would increase with any additional weight put in the boat. I may here remark, that a vessel which hoggs herself, from the end being too fine, will, for that reason, be more water-borne, and more weatherly, and furthermore she will sail faster from her fastenings being loosened from the ends drooping.

A vessel in a sea-way similar to the Madras masoolah boats in the surf, in that case the vertical effort of the sea is the agent acting, and the breadth of the ship the arm of the lever. The effort of the wave is to place the deck parallel with the slope of the sea, the resisting power, being the power of gravity, to keep the deck parallel with the horizon, so that in a sea-way diminished motion is secured, as the center of displacement is below the plane of the water-line, whereas, in smooth water, stability, or the least motion, is secured, as the center of displacement is near the plane of the water-line.

The stability of a vessel consists, 1st—in her formation; 2dly—the upward pressure of the water; and lastly—the disposition of the weight or cargo on board the vessel.

Affix two bamboos to the keel of a boat, and their upward pressure will make the boat tender; but affix them to the boat at the surface of the water, one on each side, as practised by the Burmans to give stability to their canoes, and they will produce stiffness or stability. Stability increases as the base of support is expanded at the centre of displacement, and, as that centre, is near the surface.

" On a reference to the case of three French seven-
" ty-fours, we shall be convinced how essentially the
" formation of a vessel contributes to her stability.
" The Scipio, Pluto, and Hercules, were found so
" crank as to render the lower deck guns deficient
" and dangerous. It was thought restowage would
" remedy the defects: the Scipio was unloaded, and
" again stowed, under the direction of the chief en-
" gineer. In her first stowage, she had eighty-four
" tons of iron, and one hundred tons of stone ballast,
" and was reloaded with one hundred and twenty

" tons of stone ballast, and one hundred and ninety-
" eight tons of iron ballast; and as her draught of
" water or displacement could not be altered, it was
" necessary to diminish one hundred and thirty tons
" of water, in order to preserve the same load water
" line; by these means one hundred and thirty-six
" tons were placed in the second loadening, eight feet
" lower than in the first; yet when the ship was com-
" pleted with the new arrangement of stowage, she
" was found precisely as deficient as before, inclining
" twenty-four inches with the men at quarter, and
" guns out on one side. She was afterwards dou-
" bled with light wood, to the thickness of a foot at
" the extreme breadth, and ten feet under water,
" decreasing to four inches length and depthways,
" which corrected the defect."

The stability arising from the resistance of the water is proved in boats with sliding keels. Let down the keel when the boat is under sail, and the inclination or heel over is considerably diminished, as well as the sudden roll prevented.

The upward pressure of the water is manifest on a vessel that has one side broader than the other. I well remember the mortification I endured when a boy, to find the inclination of my little boat increased when I reduced the side of the boat (under water) that swam deepest; and, on the contrary, how unbounded my joy, on discovering, that by reducing the side of the boat under water which swam the highest, I remedied the defect. Attach a piece of iron to a round spar in the water, and it will turn round till the weight is beneath: take away the piece of iron, and place a piece of cork or bamboo instead, and the spar will turn round until the lighter body comes to the surface of the water.

A round spar has no stability, whereas a half round spar has the greatest; it will sustain a weight nearly equal to its own, which no other piece of wood of the same diameter can do.

A vessel without stability lays over on her beam ends when hove to in a gale of wind, in which position the water cannot reach the pumps, which leaks in by the straining of the upper works, scuttles, ports, &c. The rudder is useless, and the vessel unmanageable; in the end, the hatches get stove in by the lee sea, and she becomes water logged.

A vessel made stiff by dead weight, is in danger of a high sea breaking on board, because she does not incline or lie over quickly by the force of the wind, but remains to be struck by the body of the sea; while the sudden weather roll, in consequence of being so struck, not only endangers her masts, but exposes the deck to the succeeding sea. One sea breaking on board accelerates another, until every thing is washed from the deck; perhaps the hatches get stove in, and the vessel ultimately founders; whereas a vessel with natural stability, i. e. having buoyancy and stability united, is uplifted and inclined by the base of every approaching sea. A tender vessel strains and labours less than a broad stiff ship.

The experiments made by Charles Gorre, Esq. of Weimar, to ascertain the form best adapted for stability, in smooth water, were as follows: This gentleman caused four bodies or models to be made, three feet in length and two in breadth, precisely of the same specific gravity and capacity. One model was square; the second was circular, that is, "the " immersed part was half a circle. The immersed " part of the third a flat bottom, with angular sides; " and that of the fourth was the form of a triangle or " wedge. The second model drew one fourth more " water than the first, or square body. The third " drew one half more than the first, and the fourth " drew as much again as the first.

" To prove their respective stability, the weight " was fastened to a line whose end was made fast to " the top of a stick, erected by way of a mast in the " center of each body, and passed over a pulley in an " opposite stanchion, which worked in a groove to " admit of depression, so as to be horizontal with the " head of the mast, when the figure became heeled " or inclined. The power being thus always horizontally applied, was similar in effect to the force " of the wind.

" The results of the experiments with a 12lb. power " applied, were as follows:—

" The circular model inclined		29°	40′
" Square do. do.		30°	10′
" Partial triangle	do.	35°	12′
" Triangular	do.	37°	"

" When the models were at their utmost inclination, the line was suddenly cut that suspended the " weight, to prove the degree of inclination they had

" to recoil or roll to windward, when it was found " that the inclination to roll was nearly in an inverse " ratio to the stability, as the circular model heeled " to windward,

" Or recoiled, ...	33°
" The square model, ...	29°
" " Partial triangular, ...	27°
" " Triangular, ...	23½°

It it evident, from the above experiments, that although the circular bottom has the greatest stability, yet it has the greatest tendency to roll, while the triangular or sharp bottom possesses the least stability, but has the least tendency to roll: therefore a vessel's bottom must have the above qualities judiciously united, which may be done,

1st. By allowing the fore body under water to pertake of the circular form; and,

2dly. The after body to assimilate to the triangular form.

3dly. The main body can be formed agreeably to the service intended; for instance, a vessel for speed only, may, from being shallow, and requiring depth in the water for weatherliness, have great rise of floor; whereas a steamer can have her main body plan on the double canoe or fallen floor principle; it deserves remark, the form of the floor does not affect velocity.

A vessel which is proportionally broad, has great stability, but is an unsafe sea boat in a violent sea, because her great breadth offers so large a surface for the vertical effort of the sea to act with leverage power to place the deck in a position parallel with the slope of the sea, and whereby an extremely dangerous weather roll is produced. Such is the vertical repelling power of a high sea on a broad vessel, that it neutralizes or destroys the power of gravity, which, in a narrow vessel, would act on the pendulum principle to keep the deck parallel with the horizon.

A narrow vessel has less weather roll than that of a broad vessel, from three causes; firstly, her center of weight is proportionally more depressed below the center of rolling motion; secondly, the surface, or center of lateral resistance, being proportionally below the center of rolling motion, retards the weather roll on the sliding heel principle; and thirdly, the force of the wind has greater power on the masts to check the weather roll. Two vessels of the same capacity, one to be three times the breadth for her length, the other vessel to be six times her breadth, it is obvious that the center of displacement would be lower in the narrow vessel than that of the broad vessel. A broad ship not merely acquires a greater degree of rolling motion, but also a greater degree of pitching motion, than a narrow ship; firstly, because the center of pitching motion continue shigher; and secondly, her extremes are shorter.

Stability is obtained, as the base of support is expanded. The Calcutta dingy, for instance, from her platter form, obtains stability as she is depressed into the water, by expanding her base of support, even though the weight be placed on deck, viz: the deck full of passengers.

Stability increases as the vertical effort of the water increases at the extremes of the base of support; for instance, the wedge shaped or triangular model has least stability—because, firstly, the base of support is contracted at its center of displacement; and secondly, because the extremes are not water borne; whereas, let the same model be divided longitudinally, and be transposed to represent the double canoe, when not only the base of support will be expanded at the center of displacement, but the vertical effort of the water is increased at the extremes of the base of support.

Stability is also increased in proportion as the center of lateral resistance is depressed below the center of rolling motion, by means of false or sliding keels, the dead wood and gripe.

Being taught by experience in the brig Bucephalus, which had a great rise of floor, that the form of the floor did not govern velocity, I built an experimental schooner called the "Original," on the double canoe or fallen floor principle, length 45 feet, breadth 9 feet, depth forward 5 feet, after 6 feet, to sail 3 feet by the stern. She proved to be a fast sailing fine sea boat; she traded during the S. W. monsoon between Rangoon and Tenasserim Provinces for several years.

I made two fir models, of the same weight and proportion, five times the breadth for length. They both sustained the same weight on deck. I then removed the keel, and hollowed out the bottom, to represent the double canoe of one model, when it then sustained fifty per cent. more weight before it upset. It of course had less buoyancy.

Length seems to be unlimited; that is, so long as the vessel has sufficient stability for the seamen to walk the deck to take in the sail, while the vessel is under a heavy press of canvas; consequently it is important to ascertain the form of greatest stability with the least breadth.

And as a vessel of the least specific weight, or which is composed of the lightest materials, is the most buoyant; and since even a tender vessel can be made stiff without detriment to velocity, by adding a temporary planking of the requisite breadth to the fore body, a few feet below the light water mark, to a few feet above the load water mark, commencing at the bow, and terminating at midships; it follows hence, that stability, velocity, and buoyancy, can be united in the same vessel.

Observations, &c. on Buoyancy and Capacity.

The circle is the form of a solid of the greatest capacity, but it has no velocity. If, for instance, the sides of a tube or the sides of a leather bucket be collapsed, their capacity and buoyancy are diminished.

An empty cask has buoyancy, but no stability; whereas a half round spar, possessing the same specific gravity as water, has stability, but no buoyancy.

A ship made of fir is more buoyant than one made of oak; and, every thing else being the same, the fir vessel will strain and labor much less in a gale than a vessel built of heavier wood.

In a sea way, a very buoyant vessel is subject to great motion from the centrifugal force of each wave or sea; witness the difference between a light or loaded masoolah boat in the Madras surf. Again, conceive a catamaran to have a quantity of ballast fixed to its bottom, or under side; nevertheless it would be in danger of being upset by the centrifugal force of the surf or sea in certain positions. On the other hand, let the same ballast be fixed to the side of the catamaran, so that the catamaran shall swim on its edge instead of its flat; in this position the force of the earth's gravity would predominate to keep the upper edge parallel with the horizon, because its center of weight is below the center of displacement, which again is considerably further beneath the surface than was the center of displacement while it floated on its broad surface. A buoyant empty case, three feet square, will have its center of weight at the center of the case, whereas it may not draw three inches of water when afloat; in which event the center of displacement would be but one inch below the surface, whereas the center of weight of the case would be sixteen inches above the water's surface; nevertheless, the empty case would sustain nearly. the same weight before it upset, as a similar floating body of the same specific gravity with water. A buoyant boat built for the Calcutta pilots, was found to have too much motion, which retarded pulling in a seaway.

The iron pilot brig Fame in a cross sea rolls deeper in her weather rolls than the other pilot vessels, which is to be attributed to her buoyancy. A buoyant vessel, to avoid top hamper and instability, should be built proportionally shallow.

Remarks, &c. on the Form of a Vessel best adapted for Velocity.

It was demonstrated in the second chapter that a vessel whose center of displacement was farthest removed from the stern, (every thing else being the same,) would, with the same propelling power, obtain the greatest velocity; that is, the vessel which has the longest run will sail the fastest. All water lines should be segments of circles; 1stly, to reconcile buoyancy and capacity with velocity; and 2ndly, in order to give to the water lines the same continuous angle throughout.

Such is the power of resistance, that an iron ball falling through the air acquires a given rate of velocity, when its accelerative force is overcome by the void generated by its passage through the air. On the same principle, a vessel having a concave run, would, on being propelled through the water, generate a vortex sooner than a similar vessel with a straight or convex run.

Every vessel possesses a certain degree of velocity, and many of them can obtain their utmost speed in smooth water under their skysails. Many fine built ships sail equally fast under their jury masts, as when they are properly masted.

The rudder may be considered the index of velocity; for in proportion as the eddy water or vacuum increases about the stern, the power of the rudder diminishes, until it ceases to have the power to steer the vessel, save within three or four points each way; hence arises the inability and the danger to scud in a strong gale, even when it is favorable.

The motion arising from pitching, is the principal impediment to velocity—

Because, 1st. By the run and after body being suddenly raised out of the water, a vacuum is created.

2ndly. By pitching, a greater quantity of water opposes the advance of the vessel; and,

3rdly. By the pitch, 'scend, or lurch, the direction of the vessel's course is altered, while the effect of the wind on the sails is thereby diminished.

The principal cause of the extraordinary motion in vessels consists—

1st. In the formation of their bottoms: witness the boats in the river Hooghly, particularly the bhur, paunceway, and dingey, which, from being water borne in midships only, are set in motion by the least ripple or agitation of the water, or by the least weight laid suddenly on either extreme; whereas the Burman canoes, from being water-borne forward and aft, will sustain a large gun on the bow, and not acquire one twentieth of the motion, in the same sea, which the dingey, paunceway, or bhur would have had;—2dly, from proportionally greater breadth; and, 3rdly, in the position of the center of weight or gravity. Let two vessels, for example, of the same size and construction, be laden, one of them to have the center of weight or gravity placed some distance abaft the midships, the other with the center of weight the same distance before the midships; propel them at the same rate against a head sea, and it will be seen, that the one whose center of gravity was farthest forward, opposes the greatest resistance to the upward pressure of the head sea, and therefore is less moved or lifted than the one whose center of weight was farther aft. Hence it follows, that vessels intended to have velocity should be formed,—

1st. With a long run.

2dly. Should be made water borne as much as possible, particularly the after body; and,

3dly. Should have the center of weight carried well forward.

4thly. Have the main frame of the form of greatest stability with least breadth.

If it were not notorious, that length gives velocity, I would refer to the flying proa; but more particularly to the inhabitants of Rangoon, who, on being asked how many days a canoe will reach Ava from Rangoon, inform you, that if the canoe is four cubits broad, a month will be required; if three cubits, then 10 days. I scarcely need observe, these dimensions refer to canoes of the same length. Canoes, however, require but little stability, from their not using sails, particularly on a wind.

Since, therefore, that vessel which is most water borne, and having her centre of weight at the same time most forward, will acquire the least motion in a seaway, and since the vessel with the least motion and with the longest run will obtain the greatest velo-

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city, being propelled in a seaway by the same power, it is hence manifest, that without detriment to velocity, additional breadth may be given at the area of flotation, at the fore and main body of a full built vessel, when additional stability or buoyancy is required.

Remarks, &c. on the Run and Stern.

The principal point in the formation of the run is, to steer well scudding before a strong gale, which is done by forming the vessel to have a long run, and to sail by the stern.

In proportion as the after body is water borne, the tendency to 'send aft is diminished; therefore the after body should be rendered water borne as much as possible; this is done by the run being formed of convex, instead of hollow water lines.

All recent experiments in steamers demonstrate that additional length of run, all else being the same, gives speed; an argument elucidating the necessity of knowing the form of greatest stability, with the least breadth in order to work out a theory of design by force of practice. A machine may be perfect, and yet the machinist be ignorant of the hidden theory. On the other hand, the skilful artist, or practical astronomer, knows what art ought to borrow from science; whereas the naval theorist, the late surveyor of the navy, caused both art and science to retrograde by an increase of breadth to shorten the run. Mean while, as our stationary state of ignorance in regard to the elements of design, arises from the nation having deprived our practical seamen of the agency of mental freedom, by treating them as state galley slaves, this consideration is sufficient reason to advocate the commencement of a system of discovery, which should begin at the beginning. The immersed part of the after body being of a conical form, of which the midship section is the base, and the length of the run the height, consequently by contracting the base, or breadth of the vessel, or by lengthening the after body, the angle of the cone is diminished. A long run accelerates velocity, and improves steerage, to admit of a small rudder.

Vessels intended for smooth water can have low broad transoms, for better accommodation or greater stability; but in a sea way the transom must be high to allow the stern 'scending, thereby to facilitate the bow to rise over the head sea. It is the low broad transoms of the schooners belonging to the Maulmain flotilla which renders them unsafe sea boats in a sea way. The sea strikes a low counter with a violent alarming shock.

A raking stern-port admits of uniting low broad quarters to a high transom, and it offers a better surface to prevent being pooped while scudding before a high following sea. The after rising line should govern the rake of the stern timbers, to which line they are a finish. Perhaps the angle at the quarter timbers, from the load water line to the lower height of breadth or bend line, should not be less than 20 degrees with the horizon. A raking stern gives it a lively and light appearance, resembling a water fowl about to take to its wings. A ship resembles in some degree a sensitive plant, inasmuch as seamen, while below, know when the vessel is overpressed with canvas. A thing,

> " By earth attracted, and by sea repelled,"
> " Which walks the waters like a thing of life, "

and which VOID—an IMMATERIAL NOTHING, of her own creation—can retard or accelerate her speed.

The prostrate practical sailors by force of convention, were taught to look up with awe and reverence to their oppressors, as men possessing superior nautical attainments. Perhaps the difficulty to grapple with the fugitive elements of ship building so as to determine the right beginning or right direction to make the researches, may have fortified or hedged in that delusion with other insurmountable difficulties; nevertheless, paradoxical as it may seem to the reader, the great stumbling block in the way of working out the elements of naval design is that mental incubus, *Naval Despotism*, together with the union of church and state, which inculcate passive obedience to the existing state of things, instead of passive resistance to certain bugbears that impede the advancement of intelligence and developement of our naval resources; which also impede the discovery of naval scientific principles, of which the custom of impressment is an instance.

From a consideration of the elements evolved in resistance, and of the warping influence on the result of experiments arising from imperfect machines, or unpractised experimenters, it would almost seem that the experimental vessels ought to be themselves based or made on a sound theory, before the elements of design can be worked out by practice, to enable the designer to supply the builder with a scientific design.

None but the rich and powerful can pretend to test a course of experimental vessels. The amateur sailor accustomed to smooth water prefers a broad ship because she is stiff; yet a blockading squadron of broad ships might place the state in jeopardy, if caught on an enemy's coast in a violent gale. To be ignorant of the laws of resistance is to be ignorant of the laws of nature, and when to this we add that the experimental vessels are of various forms and proportions, which again require that different modes and rules be applied to them, is it therefore to be wondered at, that our experimenters or amateur seamen should fail to work out a sound theory of design?

Remarks on the Formation of the Bow.

The principal points to be attended to in the formation of the bow are,—

1st. To diverge and divide the opposing water with the least difficulty.

2dly. To assist the vessel to rise buoyantly over the sea; and,

3dly. To prevent plunging into the sea.

4thly. Weatherliness. A raking bow has several practical advantages; for instance, it protects a bold gripe from the chain cable; again, a large gripe facilitates weatherlyness, and a weatherly disposition diminishes the direct resistance of the water on the depressed or lee bow.

The experiments of the Chevalier de Baut go far to shew, that the formation of the head of a vessel is of less importance in overcoming the *vis inertiæ* of the water than it has been considered heretofore. He found, "by an instrument consisting of a square "brass plate, pierced with a great number of holes, "and fixed in front of a shallow box exposed to a "stream of water, the remarkable circumstance, that "in great velocities the holes at the very border, and "even to a small distance from it, not only sustained "no pressure, but even gave out water."

A long bow necessarily contracts the length of the floor, and length of the run, and by lengthening the overhang of the fore body, increases the disposition to pitch.

A very bluff, or upright bow, in its passage through the water, raises a mound of water or small sea before it, by which the resistance of the water is increased in the manner shewn by M. de Baut's experiments; for "when the box with the brass plate in front of it was not wholly immersed, there was always a considerable accumulation of water against the front of the box, and a depression behind it." Besides, a bow too full below meets with increased resistance, because the pressure of the water increases in proportion to the depth: on this principle, "a leak 16 feet under water will admit sixteen times as much as a leak at the surface." For the same reason, the lowest immersed half of the ship meets with considerably more resistance than the half near the surface.

A middling full bow, not only admits the fore body to be considerably water borne, but likewise allows the center of weight being carried forward: then by the bow raking forward 20 to 30 degrees, at the same time to flare or flaunch out from the light water mark to the gunwale, the opposing water, by receiving the greatest divergency, would be divided with the least difficulty, while the rake of the bow would give it a tendency to rise over the sea, and the flare or flaunch out would prevent the bow from being plunged deeply into the sea. This form of a bow assimilates in a great degree to that of a grab; and the grabs (particularly the grab Nancy) are some of the fastest sailing vessels in India.

A steamer from not being so much pressed on her side, as that of a sailing vessel, can have a proportionally full or buoyant bow, at the bend line upwards, than that of a sailing vessel.

"Captain Hutchinson, in the year 1746, was in a "middling full built ship, called the Pearl, that was "taken in light wind by a squadron of sharp Toulon "built ships; but afterwards, when it came to blow "so strong as to put us under close reefed topsails "upon a wind, our vessel could be the headmost and "weathermost ship of their fleet. I had afterward," says Capt. H. "the command of a very extraor-"dinary sharp slight ship, built at Malta, with very "small scantlings of timber and plank, long, low, and "narrow, being only twenty-seven feet beam to eighty

" eight feet keel, with shelving, shallow, sharp, main " body, low buttocks for a cruizing ship, which purpose she answered well in light winds, fine weather, and smooth water. In chasing large, with a " little wind and a head swell, we have steered right " up the chase, when all their endeavours could not " keep their ship's head to the swell, but lay broadside to it. A small pressure of wind and sail would " put this shell of a ship to her utmost speed: so that " we never desired the wind to blow with a greater " velocity than about 10 miles an hour." " But in " tacking, when it blowed so fresh that we could just " carry whole topsails, we were obliged to haul up " our courses to make her sure in staying, otherwise " she would get such sternway before she brought " the wind ahead, as prevented her from staying. " This ship was so weak, that in bad weather, when " the waves ran high, we could hardly keep her together; and in chasing to windward at such times, " she used to plunge her over sharp bow so deep " into the waves, as to oblige us to shorten sail, and " add bailing to pumping, to save her from sinking.

It is the facts which observant seamen of Captain H's stamp has recorded that assist the practical genius to discover the elements of design, or to elucidate them after they are discovered, much more than that of the elaborate mathematical calculations of the learned pedagogue or mere copyists, and hence the value of nautical owners, and the value of giving to a particular class of long ships a long run in practice. It may be conceived that had our impressed seamen had the full value of their labour after being impressed, many South Sea whalers would have been owned by them, to assist science and genius to work out the elements of design by means of their recorded experiments.

By the bow being proportionably short, it admits of the floor and the run being proportionably long, qualities absolutely necessary to produce velocity. By a long floor, I mean a lengthened horizontal line of bearing about the floor heads.

The entrance of the bow should be similar to the life-boat built by Mr. Greathead, but not so fine. The stem to have about half the rake of the stem of a grab. The sweep for the bow at the load water line should be that recommended by Capt. Hutchinson, namely, half the three fourths of the main breadth. The upper sweep, or sweep of the gunwale, should be a semicircle from half the main breadth; then, by reconciling the load water sweep with the sweep of the gunwale with some concavity, it would give the necessary flare aloft. A bow formed as above, appears to me well adapted to divide the opposing water, raise the vessel over the sea, and to prevent her from plunging deep into a head sea.

With regard to the form best adapted to go smoothly, little remains to be said, it being evident, that the vessel which possesses the greatest horizontal line of bearings, or being equally water borne forward and aft, will have the least motion, and therefore pass through the water with the least pitching motion. Some attention, however, is necessary in the distribution of weight or cargo: care must be taken not to carry dead weight into either extreme, as neither of them are water borne. If the after body, for example, were cut off at the commencement of the run, it would swim several feet deeper than the main body. The same would happen, but in a less degree, with the fore body, were it cut off at the termination of the entrance, or by the fore channel.

Remarks &c. on the requisite Strength for a good Sea Boat.

Without reference to the preceding remarks, it is obvious, that every additional weight in a vessel, whether it arises from large or heavy scantling, extra fastenings, sleepers in the afterhold, &c. &c. is detrimental to buoyancy, to velocity, and to the general safety of the vessel.

Owing to the extraordinary fastenings which are absolutely necessary to connect and support the disproportionate parts of overbuilt burthensome vessels, and of rendering others sufficiently strong to take the ground, from long practice, ship-builders have acquired the habit of giving unnecessary strength and weight to the finer class vessels. To be convinced of this, we need only examine the many old crazy vessels that have encountered the heaviest gales, which, on being broken up, excite our astonishment that they had held so long together; or to examine the many slender built privateers, smugglers, &c. that navigate in the worst seas, and weather with the greatest safety.

It is notorious that the masoola boats on the coast of Coromandel owe their safety and their velocity to their buoyancy and pliability; while it is evident, that all vessels sail worse by being immoveably bound with extra fastening, &c. &c. The superior sailing quality of the Sea Witch is in part to be attributed to her pliability on the masoola boat principle; their bottom bend with the wave.

In a sea way, the water frequently leaves the after body entirely; in which case the whole weight of the after body is supported by the main body; from this cause the butts between the main and after body invariably complain first. Hence the advantage of long and narrow planks in the top sides and bends.

The round stern introduced into the navy by Sir Robert Sepping, is an invaluable improvement in ship-building. In the first place, a ship being taken aback in a heavy sea, is in no danger of going down stern foremost, which square stern ships are very liable to. 2dly—the round stern facilitates convex water lines being given to the run instead of concave. 3dly—it dispenses with a proportion of dead wood, fashion pieces, &c. 4thly—it admits of the whole scantling being reduced about the stern; and 5thly, giving additional bearings and support to the after body. These are some of the advantages of a round stern. The additional expence is the great drawback in this economical and competition age to the circular stern.

A well formed vessel does not require half the size of scantling as the burthensome overbuilt vessels require.

In 1823, I was in a well-formed native brig, in the Bay of Bengal, laden with 4000 bags of rice, equal to 300 tons; and her timbers and beams were only 5 by 4 and 3 inches, and her planks were from 2 to 1½ inches thick. We experienced a fresh breeze for several days, when I was delighted with her liveliness and buoyancy. This vessel however was not intended to beat against the monsoon.

Long planks well fastened in the top sides, and in the upper deck, add considerably to the strength of a ship.

CHAPTER IV.

OBSERVATIONS ON THE EVOLUTION, &c. OF VESSELS.

On the Form best adapted to hold a good Wind, and to sail fast by the Wind.

A ship in a sea way sailing close by the wind loses more than half her speed; whereas in smooth water she loses about one eighth her speed.

As the pressure of the water increases in proportion to the distance from the surface, it follows, the more water a vessel draws, or the more she is depressed into the water, the greater will be the resistance. Wherefore,—

1st. The lower the center of lateral resistance is situated, or the greater the superfices of the keel or gripe, the less will be the lee way or drift. And,

2dly. The lower the center of displacement is situated, the less will be her direct velocity in smooth water, and the less will be her pitching motion in a sea way.

A vessel formed to sail by the stern, will sail faster, hold a better wind, and work better in a sea way, than a similar vessel formed to sail on an even keel, for the following reasons:—

1st. Because from her center of displacement being higher, consequent of her greater breadth and greater weight in the forebody, she meets less head resistance, and acquires less motion, and therefore obtains greater velocity.

2dly. From her center of lateral resistance being lower, she makes less leeway or drift; and,

3dly. From her center of rotatory motion being farthest aft, she works better, as will be explained hereafter.

The Virginia pilot boats, the Irish hookers, and similar vessels, formed to sail considerably by the stern, are capable of fetching in, even to windward of the place at which they looked when the tack was first commenced. This arises from the lesser quantity of water that opposes the weather bow and fore body, whereby the natural disposition of the vessel to luff to windward is facilitated; so that, at each 'send and pitch, the fore body is enabled to fall to windward of the place from whence it rose.

This quality is evidenced in the fine formed grabs.

A vessel being trimmed by the head, requires considerable weather helm to keep her out of the wind, when sailing with the wind a-beam, or close hauled; this is owing to the center of lateral resistance or rotatory motion being removed forward, whereby the impulsion of the wind on the hull, sails, and masts, is so far increased as to act upon the after body of the vessel, similar to a weathercock.

A tender, crank vessel, sailing with the wind a-beam, or close hauled, equally requires considerable weather helm to keep her out of the wind. This arises,—1st, from the increased resistance of the water on the depressed or lee bow, while the resistance is diminished in an equal degree on the weather bow: and, 2dly, by the inclination or heel of the ship, the center of *direct* impulsion of the wind on the sails or direct attraction before the sails is carried to leeward, by which means it has the greater effect to force the vessel up into the wind.

For these reasons, on the near approach of a squall, or as the breeze freshens, the officer of the deck instinctively orders the helm to be put a-weather, to keep the ship from flying up into the wind.

A large rudder placed at a great angle, considerably retards the velocity of a vessel.

And since additional breadth at the fore body would produce additional stability, and keep the center of weight more forward, and center of displacement nearer the surface; and as the center of lateral resistance is lowered in proportion as the after body is allowed to descend into the water, it follows that a vessel, to sail fast by the wind, and to hold a good wind in a sea-way, should be formed to sail considerably by the stern, having a bold gripe to counterbalance the fine run.

Observations on the Form best adapted for Tacking in a Sea way.

The bow sea is the principal obstacle to a vessel coming about in stays. So great is the power of the bow sea, that a vessel sailing with the sea on her lee bow, is frequently forced about against her helm.

Since most vessels sailing by the wind require weather helm to keep them full, it is obvious, on the helm being put a-lee, at the same time trimming the sails, the ship readily comes head to wind; and if the vessel holds her headway while in stays, or until the sea takes the lee bow, in that case the power of the rudder will bring the ship about. But when the headway ceases, it is then the office of the head sails to bring the ship about, because the power of the rudder ceases with the headway, (and remains powerless until the vessel obtains stern way.) Therefore the farther the center of lateral resistance or rotatory motion is removed aft, the greater will be the power of the head sails, when aback, to bring the vessel about; or the farther the foremast is removed forward, the head sails act with greater power on the fore body to force or turn the ship's head over the sea. It is in this position that the concave bow and deep forebody offer the greatest resistance to the bow sea, to prevent the ship coming about in a head sea.

I have frequently trimmed a boat when sailing, so that she sailed by the wind, and tacked, without the use of the rudder; this was done in the following manner: When the boat was to be put about, two or more men were sent close forward, by which means the after body was raised out of the water, whereby the wind acted on the after body with increased power to bring the boat's head to wind. When the boat was head to wind, then the men instantly shifted to the stern of the boat. Thus the center of rotatory motion is carried aft. The fore body is at the same time raised out of the water; by which means the sails aback have increased power to box, or force the boat on the other tack.

Hence it follows (every thing else being the same,) the vessel best adapted to tack in a sea way, is that which has the center of rotatory motion well aft,—the Irish hooker, for instance. A bold gripe adds to a vessel's weatherliness, and it acts with leverage power from its distance from the center of rotatory motion, to prevent the vessel swinging off in stays.

Remarks on Steering well, &c.

A vessel that sails fast, must steer well. The rudder has power in proportion to its depth in the water, that is, according to its approximation to the center of rotatory motion. Captain Schank justly remarks: "that vessels with sliding keels wanting to veer, are "to heave up the fore keel, and heave down the after keel; and if it be requisite to veer very quickly, "the main keel should be hove up also; vessels will "then turn or come round as if upon a pivot, the "rudder being used at the same time as in common "cases." The reason of this is plain; for by the fore and main keels being up, the center of rotatory motion is removed aft, which gives liberty to the fore body to yield promptly to the rudder; and as the rudder obtains power in proportion to its depth, it follows, that a vessel, to steer and veer well, should be formed to have her center of rotatory motion well aft, that is, be formed to sail by the stern.

Remarks on the necessary Properties for a Vessel to have, to scud in a heavy Gale and tempestuous Sea with the greatest Safety.

A vessel, to scud with safety, must steer well, and rise promptly to the following sea.

A vessel not being sufficiently buoyant in her after body, is in danger of being pooped, or of having her dead lights stove in by every sea; and a vessel that does not steer well, is in danger of broaching to, or in being brought by the lee.

The after body obtains buoyancy in proportion as the centre of weight is removed forward. If, for example, the centre of weight was two thirds from the stern, the after body would be more buoyant, and rise more promptly to the following sea. Because, in that case, the after body presents a lever, as it were, to be acted upon by the upward pressure of the sea. A short ship, that is, a proportionally broad ship, is impelled before a following sea with a velocity which endangers her broaching to, more so than a long ship.

"The worst consequence," (observes Captain Schank, in his remarks on sliding keels,) "of a difficulty in steering, is what is to be feared has too frequently happened, though rarely heard of, and that is, the ship's broaching to. This, though sometimes the consequence of a wild or careless steerage, is more frequently occasioned by strong gales and tempestuous seas. Thus, for instance, a ship scudding before the wind, or quartering, having little

" sail set, and that low, such as a reefed foresail, when " between two seas, is almost becalmed, and there- " fore loses her way; the next or following sea raises " her stern, her bow inclines downwards, the cutwa- " ter having a different direction from the intended " course. The stern by this is lifted up so high that " the rudder has little or no power, it being almost " out of the water. In this situation, the ship pressed " on her lee bow, by the water having got on the " weather quarter, and the ship on the top of the sea, " she flies with such violence as to bring her head " round; and then lying on the broadside, she plunges " with the greatest velocity into a high or raging sea, " the water breaks into her, washing and carrying " away every thing off the decks, frequently some of " the crew; and it is to be feared that by such acci- " dents, vessels themselves go to the bottom, and " are no more heard of. Now there is nothing more " clear and certain, than that sliding keels counteract " these dreadful effects.

" To prevent the dreadful accident of the vessel's " broaching to, no more need be done, than to heave " the main and fore keels up, and let down as much " as is thought necessary of the after keel; and if " enough of it is down, it is impossible that any ship " can meet with this."

Wherefore, a vessel, to scud with safety, should be formed to have her center of weight well forward to give buoyancy to the after body; and to have the center of lateral resistance or rotatory motion well aft, to give additional power to the rudder, and to prevent the vessel from broaching to. Scudding In a gale the whole rudder is occasionlly almost out of the water.

A vessel with her center of weight or displacement nearest the stern, that is, a full-built vessel, when laden, cannot exceed eight knots; and even then, the eddy water occasioned by the vacuum so far diminishes the power of the rudder, as to oblige the vessel frequently to heave to, in order to avoid the danger of broaching to. In the ship Triton, I experienced a very heavy gale near the Western Islands. We made three attempts to scud; and while scudding, the foresail lifted on both sides alternately, before she would answer the helm; and but that the ship was buoyant, tender, and lofty, the sea must inevitably have broken on board; whereas a vessel whose center of displacement is farthest forward, that is, having a long and deep run, will sail at the rate of 12 to 15 miles per hour; consequently she can make fine weather, and even make her passage, when a full built ship is obliged to heave to.

Remarks on the Properties, and on the Form of a Vessel, best adapted to heave to in a violent Gale, with the greatest Safety.

A vessel to be safe when hove to in a violent gale, must have buoyancy, stability, and steerage way.

Buoyancy, to rise easily over the sea:

Stability, to enable her to carry sail:

And steerage way, to admit the vessel to receive the shock of the sea at the best point, from which she would receive the least laborsome motion, and to prevent her from coming head to sea, or from falling off into the hollow of the sea.

Without buoyancy, the vessel is in danger of every sea breaking on board.

Without stability, she will lay over on her beam ends unmanageable; and with too much stability she cannot heave to from danger of foundering through violent rolling.

And without steerage way, the vessel may come up to the sea, and thereby damage or pitch away the masts, or will fall off into the hollow of the sea, where she is in great danger of every sea rolling on board.

When a ship lays to without straining, or shipping seas, then it is proverbial among seamen to commend the vessel for having " bow'd the sea."

The least laborsome motion that a vessel can have when hove to, is that which equally partakes of the pitch or rather 'scend and roll; and this motion is given to the vessel when the sea strikes her about 45 degrees before the beam, or broad on the bow. It is in this position when the high transom is found to contribute to the safe sea boat quality.

By the extreme breadth being well forward, the *base* of the approaching bow sea will then have additional power to incline the ship promptly, and thereby facilitate her rising buoyantly over the sea.

By the center of weight being well forward, the fore body will oppose increased resistance to the shock of the bow sea, by which means a vessel hove to is less liable to be thrown off into the hollow of the sea, and which a bold gripe assists to prevent.

The advantage in having steerage way when hove to, to allow of the vessel to receive the shock of the sea on the bow, is too obvious to need farther illustration.

The leeway or drift is prevented, in proportion to the depth at which the center of lateral resistance is situated: and since this center descends in proportion as the after body is immersed in the water, it follows the form best adapted to heave to with the greatest safety, is that which has its extreme breadth well forward, and (every thing else being the same) which draws the greatest quantity of water aft.

Observations on the Position and Motion of the Mast.

Since the center of lateral impulsion of the wind on the sail, hull, masts, &c. is opposed by the center of lateral resistance of the water, and since the action of the rudder to preserve an equilibrium between those centers considerably impedes the vessel's velocity, it follows that the masts should be placed with reference to the center of lateral resistance.

If a vessel could be formed to remain upright, sailing with a fresh breeze on her beam, or close hauled, or otherwise, so as to prevent the inclination of the vessel to fly up into the wind; in that case, the center of lateral impulsion of the wind on the sails, &c. could be placed directly opposite to the center of lateral resistance of the water; but as this cannot be done, the center of impulsion must be placed before the center of resistance, to counteract that inclination. Vessels with the least stability, have the strongest inclination to luff up into the wind: consequently the center of impulsion should be proportionably more forward of the center of resistance, in tender crank vessels, than in those possessing a greater degree of stability.

When several minor causes operate in favor of one quality or property, the unscientific experimenter is apt to attribute the effects to a wrong cause; for instance, motion in the masts sometimes diminishes the propelling effect of the sails. This is demonstrated in a boat under sail, when the oars are also used; as witnessed in the reed, or the tree yielding to the breeze, to diminish the force of the wind. Motion in the masts affects the angle of those yards the weather braces whereof are fastened to the hull of the ship to accelerate velocity. Motion in the masts causes the vessel to advance, on the same principle as the mere motion of a person in a small boat can impel the boat. Again, motion in the masts tends to make the vessel work, which facilitates velocity.

Illustrative of the fact of how small an angle effects the accelerative force of a vessel;—two vessels, for instance, being ready for launching, with their launching ways laid with the same angle, viz. one inch to a foot—one a heavy lofty vessel, the other a low slight vessel—it would be seen that the heavy lofty vessel would be launched with facility, while the low light ship would not launch unaided by exterior force, and this because the center of weight of the lofty vessel would fall much farther beyond the point of a perpendicular line, erected from the ways, to pass through the center of weight, than that of the center of weight of the low vessel. Reaction is equal to action. The difficulty lies in discriminating the state of the transition state; that is, when the agent acting becomes the agent acted on. Masts placed in the extreme of the vessel will not only impart violent motion to the vessel, but will receive violent motion from the vessel's motion. Again, in sculling a boat, the oar in passing edge ways through the water meets little resistance to regain the position at which power may be applied by the sculler. In this instance the water, the sculler, and the oar, constitute the acting agent, and the boat the agent acted on, whereas, when the boat is propelled by the mere motion of a person, the man and boat is the agent acting, and the water the agent acted on. A boat's head may be turned by a sudden move of the rudder, that is, by allowing the rudder of itself to regain the midship position, to repeat the operation, so that if several rudders be affixed along each side of a boat, say two at the after body, two at the main, and two at the fore body, when by a sudden jerk of the rudders, assimilating, as it were, to the action of the fins of a fish, the boat would be propelled.

The nearer the masts can be placed to the center of perpendicular motion, (without the sails on one mast intercepting the wind from the others,) the greater will be the propelling effect of the sails, and the less the masts and vessel will labor and strain.

A vessel formed to stay well, admits of her foremast being placed proportionably more aft, or nearer the center of perpendicular motion: witness many of the brig privateers out of America.

Masts that rake aft, give to the sails a tendency to raise, and assist the vessel over the sea. To be convinced of this, we have only to call to mind the effect of the wind on the boys' kite in the act of flying. Besides, by having a rake aft, the masts are less liable to being pitched away.

Long lower masts and short topmasts are far preferable to short lower and long topmasts:

1st. Because they can be rendered doubly more safe and secure from being carried sway. The difficulty and anxiety to secure a long topmast, while the vessel is laboring in a high cross sea, is known to every experienced seaman.

2dly. Because long lower masts admit of lofty and large trysails being set; which sails are preferable, for heaving to with, to either the main topsail, course, or staysails, in so far that they give the vessel steerage way, and at the same time allow her to lay within five points of the wind and sea. Whereas, when hove to under the close reefed main topsail, from not having steerage way, she comes up and falls off at pleasure. And when hove to under the foresail, she lays nearly in the hollow of the sea, and under the staysails the vessel cannot be kept steady, from their being too low. Besides, a vessel hove to under trysails is in no danger of going down stern foremost, when taken aback. Withal they are much easier taken in, and with less risk of splitting in a gale of wind, then either the topsail or foresail.

And, 3dly. The long lower mast, by admitting a pole topmast and topgallant mast (in one spar) to reeve and fidd, the topmast caps, the heel of the topgallant mast, and in many cases even the topmast crosstrees, could be dispensed with. The relief thus given to the masts by this reduction of weight from the mast head, may be accurately estimated by those seamen who have witnessed the relief afforded to the masts by sending down the topgallant yards in a cross jerking sea.

Remarks on Vessels intended to navigate in shallow Water.

It was seen, that a vessel intended to work off a lee shore, and to sail fast by the wind, must be deep in the water aft, and have a good gripe or entrance, to hold a good wind; and it is manifest, that a vessel intended to navigate in shallow water, must have a flat floor, that is, a flat bottom, in order to draw the least water.

Vessels with a flat floor, similar to the bottom of the transit constructed by Capt. Gower, are admirably adapted to navigate in shallow water. Auxiliary means must be resorted to, however, to supply their want of depth, so as to increase the lateral resistance of the water, as well as to give the center of rotatory motion its proper position. This can be done by means of two or more additional keels or bilge-pieces, sliding keels, lee-boards, or a bold gripe.

These vessels may preserve the same form in every other respect, save their flat bottoms, as those vessels intended for velocity, and to work off a lee shore in a heavy sea.

Riding at Anchor.

A vessel that goes smoothly through the water, has sufficient buoyancy, sails fast, and steers well, must ride easy at anchor.

Conclusion.

In the preceding observations, it has been shown,—

1st. That breadth, and likewise formation of the main frame, gives stability; that stability from breadth facilitates velocity in smooth water, but destroys the safe sea boat qualities in a violent gale, and besides in a head sea it increases the pitching motion to obstruct velocity.

2dly. That convex water lines unite buoyancy with capacity.

3dly. That velocity is produced in proportion as the run is lengthened, that is, preserving an even conical form, and the extremes being water borne.

4thly. That depth, that is, the after body being deep in the water, enables the vessel to hold a good wind, to work, to scud, and to steer well, and prevents the rolling motion. And,

5thly. That the nearer the center of displacement is to the surface, the less will be the resistance of the water.

Therefore, by carrying the extreme breadth well forward—

1st. Admits of the run being made proportionally long.

2dly. Gives the least laboursome motion to a vessel hove to in a heavy gale, and facilitates her rising buoyantly over the sea.

3dly. Prevents the fore body being depressed into the water; at the same time it admits of the after body descending to its required depth. And,

4thly. Admits of the center of weight being carried forward.

Hence it follows, that vessels should be formed with their extreme breadth well forward.

It was likewise demonstrated,—

1st. That in proportion as the centre of displacement or gravity is removed forward, or from the stern of a vessel, (every thing else being the same,) the greater will be her velocity.

2dly. That a vessel goes smoothly through the water, that is, has the least pitching motion, in proportion as she is water borne, and as her center of weight is carried forward.

3dly. That in the act of scudding, the after body obtains buoyancy, in proportion as the center of weight is removed from the stern. And,

4thly. That a vessel hove to in a tempestuous sea, would be less liable to be thrown into the hollow of the sea, in proportion as the center of weight is forward, to oppose and withstand the shock of the bow aea.

Wherefore vessels should be formed to carry their center of weight or gravity well forward.

It was also demonstated,—

1st. That a vessel, to work well, to hold a good wind, to tack, veer, and to steer well, should draw considerably more water abaft than forward.

2dly. That when sailing by the wind, or hove to, in a heavy gale, a vessel receives less bow and head resistance, in proportion to the lesser quantity of water she draws forward.

Hence it follows, that vessels should be formed to have their center of rotatory motion well aft.

Therefore the art of Marine Architecture consists in the proper disposition of the center of gravity and center of rotatory motion: and that that vessel is the most safe and perfect sea boat, which has the greatest distance between those two centers, (every thing else being the same;) that is, whose center of gravity is before the midships, at the same time having her center of lateral resistance or rotatory motion equally abaft the midship of the vessel.

In 1837, I built the bark Colonel Burney, of the following proportions and dimensions. This vessel has been in several typhoons, and heavy gales of wind. The several experienced captains who commanded her, have pronounced her to be a safe sea boat. She is very weatherly, and easy in a head sea. I believe that on her being tested by the true criterion of yards of canvas to tonnage, but few vessels would beat her on any point of sailing. We were in company with the Cambrian Frigate, Commodore Chads, off Achen Head, for several hours. When the sea was on the beam the Cambrian beat us, but when we tacked to meet the head sea we beat her.

Length on deck,	113	feet.
Moulded breadth,	20	"
Depth at main body,	13	"
do. after body,	15	"

The main body plan is one fourth the keel, or 20 feet.

The fore body plan,	20	"
After body plan,	40	"
The stem rakes,	45	degrees.
Stern post rakes,	33	"

The floors at main body have 15 degrees rise, and are reconciled to the futtocks, or side timbers by a segment of which one fourth the breadth is the radius.

She is formed to sail 3 feet by the stern. All the water lines are convex, and segments of a circle.

She is built of teak with a solid bottom, but if a similar model was built of lighter, and more pliable materials, all the qualities and properties would be improved. Or if a larger vessel of the same proportion and form were built of teak, nevertheless the sailing qualities would be superior to that of the Colonel Burney, because her stability would be improved.

No individual can carry out a course of experimental vessels on a large scale, yet nothing but actual practice can undeceive the deluded or convince a nation of its want of scientific naval knowledge against its will and prejudice. But in regard to myself, in addition to limited pecuniary means to carry out a course of experiments, my political sentiments caused my expulsion from Rangoon where I had the appliances and means by which I might have carried out other experiments on a small scale. The next best thing is to assist the amateur designer with the following outline, wherewith to rough draft a block model, composed of six or more pieces of plank, so as to embody their peculiar ideas into a tangible form for the benefit of naval science.

My son, who commanded the Colonel Burney for several years, who last year built the schooner Thane at Rangoon, for a timber trader, of similar proportions of length to breadth, and depth and form of floor as the Colonel Burney, but with a longer main body,

viz :	Main body,	7.16	of the keel.
	After body,	6.16	"
	Fore body,	3.16	"

" recommends that the amateur designer should make a block model of the intended vessel, (of six pieces of boards to be screwed together,) but previous to which they should make a rough chalk line draft from which to obtain the outline for the block model, in the following manner, viz.

" After the designer has fixed fully upon the proportions of length to breadth and depth; 2dly on the dimensions of the main, fore and after body; 3dly on the rise of floor at dead flat, the rake of the stern post and rake of the stem, next proceed with the chalk line to strike the outline of the *shear draft plan* on a scale say half an inch to a foot.

" Below the keel line of the shear draft strike a line to form the outline of the *half breadth* plan, finishing the extreme or deck line with a segment of a circle. Next make the main frame or dead flat, that is, the main body plan, exhibiting the rise of floor, tumble home, &c. &c.

"Assuming that half the breadth be the position of the loadwater line, strike the loadwater line on the shear draft, and from the points of its intersection at the stem and stern post let fall perpendiculars to the keel line. Next sweep the loadwater line on the half breadth plan, extending from the after main frame to the after point of intersection at the keel, and from the foremost main frame to the point of intersection at the fore end. The upper edge of the third board in the block model will represent the loadwater line.

"Again, assuming the floor heads or the extreme of the flat of the floor to be the lower water line, which we will assume to be three fourths from the keel on the half breadth plan, from that point sweep the lower water line to the stem and stern post. Now this lower water line will form the upper edge of the lower piece of board of the block model.

"From the main body plan make two chocks, similar to miniature long boat chocks, to extend to the second futtock heads.

"Having the keel, the stern post, the stem and the main frame and two water lines for your guide, the formation of two convex conical ends becomes then a mere mechanical operation.

"On the block model being complete, the edge of each board of the block model would be correct water lines for the correct draft to be given to the builder, and from which block model the relative position of its centers might be ascertained. But should he wish to become more perfect in the art of drafting, or art of laying off in the mould loft, the works of DeCreuze, White, Fincham and others, may be advantageously consulted."

Every Captain should be competent to superintend the framing of a small vessel out of a wreck, and as a very little practice in making a block model would facilitate his becoming competent to do so, he should impose this task upon himself as a part of his duty. Again, every Captain should know the rationale of a rule for masting, in the event of being dismasted.

Stability is the limits to the length of masts, while breadth and depth are the principal elements which govern stability.

Four times the inside main breadth, deduct the depth—is a good general rule for the main mast of a ship, or the fore mast of a brig. The diameter one inch to 3 feet in length.

It must be admitted that the observant practitioner and experienced master seaman is better qualified to trace the cause of the good or bad properties of a vessel after repeatedly witnessing results, that are opposed to received theories, than that of a draftsman or builder, who must receive his evidence at second hand with which to correct his preconceived opinions. On the other hand it may be easily conceived, that with respect to appearance or in regard to lines or curves of beauty, such as the cut water—the rail line or quarter galleries, these being matters of taste, a very little nautical knowledge would suffice, to qualify the builder to ascertain and determine the curve or lines most pleasing to the unscientific eye. Meanwhile the pretenders would evaporate their little talent by means of paint, &c. to persuade the unlettered sailor of their great nautical genius, somewhat like the despotic tyrant acting the popular democrat, by his tact in the art of humbug, or a painted padded termagant passing herself for a Venus, or the ready-made officers giving the initiative to the Board of Admiralty, to search for the elements of design at an enormous expense to the country. If nautical ignorance is to be thus systematically cultivated, the want or a demand for a knowledge of the elements of design would never be created or felt, and without that want every effort to elucidate a hidden theory would be a disheartening waste of mental labor. A knowledge of our ignorance is a preparatory move to improve our scientific attainments. On the other hand, to remain ignorant of our own state of ignorance, and even seem by our apathy to glory in our ignorance, the nation must retrograde in her maritime affairs. Happily the free competition, consequent on the repeal of the Navigation laws, will work out this very want, when British enterprize, and scientific attainments will supply that demand. The sheet anchor of our maritime and commercial greatness being cheap ships, and cheap government, and without science and cheap government, ships cannot be cheap.

Of the ornamental parts of a vessel, that of the curve for the cut water, the rail line and the position of the quarter galleries are the most prominent.

The Cut Water.

To form the cut water curve, strike a line of 45 degree angle, on the sheer draft from the light water mark towards the bust of the figure and divide this line into two equal parts, from the bust to the light-water line, then with the whole length of the line in your compasses find a common center inboard, with which sweep a convex segment from the bust to the center of the above line. Next find a common center before the line and sweep a concave segment from the middle of the line, to the lower water line when the curve is completed.

The Rail or Rough Tree Rail.

The rail and cut water form the out line of the ship. It is now the fashion to have the rail nearly straight. A ship which sets by the stern looks better, that is less stiff than one on an even keel. On this account the rail should be lower aft than forward, that is, the rail should droop aft one foot for every 100 feet in length; that is to say, if the rail at the bluff of the bow be six feet above the loadwaterline, and the rail be 100 feet long, then let the after end of the rail be five feet above the loadwater line. In addition to which the rail to curve downwards one foot, the place of greatest curve to be abreast the center of weight.

The Quarter Galleries.

Ill placed quarter galleries are great deformities to a ship, and as they reconcile the side with the stern, it is obvious that the rail and the curve of the stern moulding must govern the position and droop of the quarter gallery main rail. Strike a line on the quarter parallel with the rail, and set off on it half the breadth of the stern for the length of the quarter gallery rail, next set off below the fore end of this line as many inches as are in the curve of the stern moulding, which will be the place of the fore end of the quarter gallery main rail. The main rail being fixed, the finishing is a matter of taste and convenience.

Shakespeare shrewdly observes, that were it as easy to do, as to know what is good to be done, chapels would have been churches, and poor men's cottages princes' palaces. The poor however would have churches and chapels to copy from, but naval despotism having so far prostrated the intellect of our seamen and seafaring classes, which is furthermore depressed by custom, prejudice, false pride and patronage, that the mine of nautical science cannot be worked, nor even discovered, to demonstrate the elements or principles of naval design, much less a good model to copy from.

"Whenever," says Metastasio, "music aspires to the pre-eminence over poetry in a drama, she destroys both that and herself." On similar principles, whenever naval despotism aspires to give the initiative to the nautical mind, it obstructs science to destroy itself and the character of the nation. I may add, that whenever the amateur draftsmen pretend to improve the model of a vessel on principle, they strengthen quackery to retard improvement, seeing that the experimenter or experienced seaman himself is grouping in the dark from want of knowledge of first principles.

Commerce, the arts of peace, civilization and civil liberty, are nearly synonymous in their results; while ships are the principal instrument or means of commerce. Meantime Great Britain, viewed as the originator and the unmistakeble advocate of the free trade principle, in trade, government and religion, is only at the threshold of her future greatness. For this end the nation should become a ship building company, to work out the hidden theory of design and produce cheap ships. Of the philosophy and state policy to work out the theory of naval science by practice, there can be but one opinion. The question therefore is as to the best mode to make the beginning. In the preceding sheets I have recommended to adhere to some fixed proportion of length to breadth and depth, so that each vessel might be an experimental vessel, and every observant seaman an experimenter to aid in rendering the elements of design accessible to the research of science or of elucidation by the test of reason. But if naval patronage and the impress system are to exist to sap her maritime greatness, her decline and fall are shadowed forth, as intimated in the able letters of Admiral Napier.

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